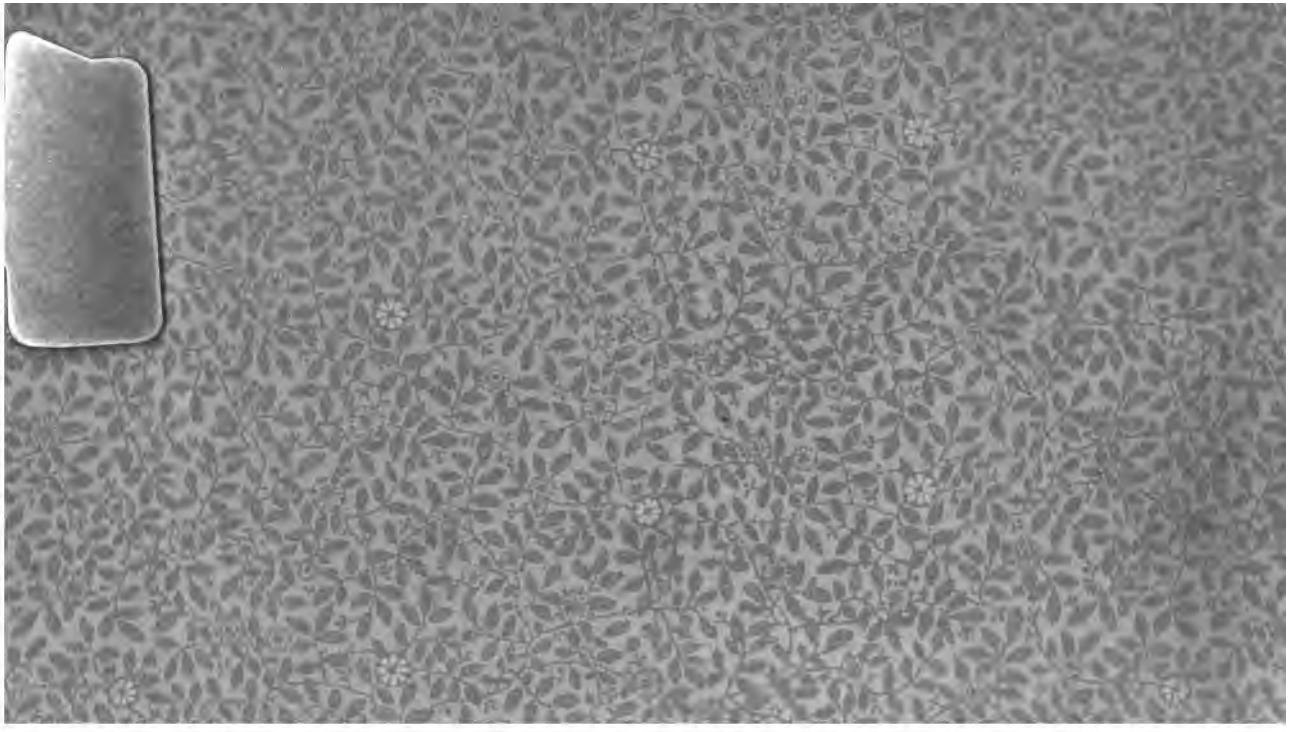
HARROGATE AND ITS WATERS

G. OLIVER, M.D.



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NOTES ON THE CLIMATE OF HARROGATE AND ON THE CHEMISTRY OF THE MINERAL SPRINGS

BY

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PREFACE.

THE following pages—mainly extracted from the writer's work, "The Harrogate Waters: Data Chemical and Therapeutical," addressed to the members of his own profession—form but part of a design long cherished: namely, to provide an outline of the numerous matters of interest which Harrogate presents to the intelligent observer—but more particularly, however, to those who care to study the chemical and geological, apart from the purely medical, aspects of this watering-place. The writer is aware that such a sketch must appear dry and uninviting to the majority of readers, and cannot, therefore, become popular: but he conceives that it may, nevertheless, contribute somewhat to broaden and deepen the foundations of belief in the efficacy of this Resort in restoring and preserving health—not merely with the few non-medical readers who can weigh, consider, and assimilate the data thus presented, but with those who can clearly recognize

the general drift of them ; and it may be acceptable to the judgment of many who prefer concrete facts to general statements and impressions, however tastefully garnished.

The gulf between plan and execution remains, however, unspanned. But, though the writer has as yet completed little more than a fragment of the bridge, he is presumptuous enough to believe that even this imperfect structure may be of use to the town of his adoption, and to some out of the many who resort to it for health and recreation ; for, though it has no pretensions to a piece of finished masonry—being but a few rough stones thrown together, with their angularities too apparent—he trusts it may be accepted as marking the track of the highway whence may be gained some truthful views of this small patch of nature; and he is the more hopeful in this, knowing that he has built with the gritstone of fact—regretting how rude the dressing—and has avoided, as much as possible, the artificial too well shaped brick so deftly moulded by the imagination.

The materials here provided may enable the reader to learn something of :—

1. The climate of Harrogate as a health-resort, viewed both from the side of Physical Geography,

and from that provided by experience—Meteorological and Medical.

2. The Mineral Waters: the latest recorded facts and views respecting their chemical constitution, and their place among other similar springs at home and abroad.

3. How far the chemical knowledge confirms the reputed and proved properties of these curative agents.

The writer regrets the pressing duties of the hour prevent him from completing his design: for he hoped ere this to have redressed this rigid outline—to have doffed its work-a-day dress of science, and to have donned it with the habiliments of ordinary public life; and—by recording his geological observations—to have opened up the enthralling vista of the incomprehensible Past, when nature folded up the health-giving stores which flow into our Present—like the fulfilling words of an all-wise seer. But he indulges in a hope—somewhat more real than a mere day-dream—that he may yet be enabled to shape for public use his notes—among them, doubtless, many guesses at truth—collected as a diversion from his more serious pursuit, from the crossed and recrossed scroll beneath our feet—the only all-true record could we but decipher it aright—of the

doings of nature in the inconceivably bygone ages, of which these Waters bear silently forward the story, and of which these Rocks are the faithful witnesses.

West End Park,
June, 1881.

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CHAPTER III.

CHAPTER IV.

ERRATA.

Page 12, seventh line, *read* "wooded" *for* "wooden."
,, 17, end of fourth line *insert* "an."
,, 20, seventh line, *read* "rain-free" *for* "rainfall."
,, 24, first line, *read* "medicinal" *for* "medical."
,, 39, thirteenth line, *read* "sulphate" *for* "sulphates."
,, 57, fifth line from bottom, *omit* "of."

[illegible] taking place in this country, and unequalled by any on the continent of Europe for the diversity and curative influence of its waters in a large number of diseases."—DR. COPLAND.

INTRODUCTORY.

THE remarkable, and indeed unrivalled array of medicinal springs with which Harrogate is endowed, do not embrace all its curative resources. Though the remedial advantages which pre-eminently belong to it as a *mineral watering-place*, seem to overshadow the climatic and hygienic properties which pertain to it as a *health resort*, the latter should not pass without recognition; for, when conjoined with the former, they frequently seem to help forward the good work of cure or relief, and even, when enjoyed alone, their restorative powers are daily witnessed, and are, moreover, highly prized by many invalids who annually resort to Harrogate merely on account of its climate.

Located in the undulating upland, which may be appropriately termed the Highlands of the West Riding, at an altitude of from 400 to near 600 feet above the sea-board, and distant from the con-

taminating influence of towns, Harrogate possesses an atmosphere remarkable for purity and freshness. The visitor—habituated even to the pure air of some rural district—at once recognises its invigorating properties, which inspire a feeling of buoyancy and capacity for increased exertion and enjoyment, but rarely induced by the air of valleys, plains, or lowlands, and even of protected uplands. But those who enjoy and flourish in the dry and stimulating climate of Harrogate more than others, are the dwellers in large manufacturing towns and cities,*

* The impurities of the air of towns have been demonstrated by the chemical analysis of the rain, which washes them out of the atmosphere. The following are a few of the numerous results obtained by Dr. R. Angus Smith, who may be called "the pioneer of chemical climatology"; they provide physical reasons of great force why the town air-breather rejoices in the atmosphere of the country, and especially in that of Harrogate, which is singularly pure and refreshing.

Analysis of Rain.

		Parts per Million.			
		Sulphuric Acid.	Nitric Acid.	Ammonia.	Albuminoid Ammonia.
Typically pure air.	Scotland-Inland country places.	2·06	·305	·532	·039
	England—ditto.	5·52	·749	1·070	·109
	Ireland-Valentia.	2·73	·370	·180	·034
Air of Cities.	London.	20·49	·840	3·450	·205
	Manchester.	44·82	1·179	6·467	·251
	Liverpool.	39·59	·582	5·380	·159
	Glasgow.	70·19	2·486	9·100	·300

or in the damp and relaxing parts of England, such as the South West Coast.

The obvious properties of the climate spring from physical conditions which should first be reviewed (Chap. I.); then may follow such experience of them as the writer has gathered from observation (Chap. II.); and finally, how far they conform to the therapeutic aims of the medicinal springs (Chap. III.).

CHAPTER I.

THE MAIN PHYSICAL CAUSES WHICH DETERMINE THE PROPERTIES OF THE CLIMATE.

General Conditions.

The position of Harrogate midway between the Irish sea and the German ocean, at a considerable elevation, is favourable to the free commingling of the higher reaches of the atmosphere extending from sea to sea, and the preservation of the marine qualities of air-currents prevailing from either. Hence, possibly *one* source of the freshness and elasticity which the air of Harrogate inspires:—qualities pre-eminent in sea-air, but much less pronounced inland except on high mountains; moreover, it may be said to blend certain qualities derived from both coasts—dry and bracing from the east, with the harshness of that quarter tempered by the mellowing influences of the west, while the moisture of the latter is greatly reduced.

To the westward the moorland plateau of Harrogate rises to higher and still higher altitudes; those within view—a radius of 15 miles—Brimham and Pately moors, Greenhow Hill, Simon's Seat, Blub-

berhouse moor, Rumble and Ilkley moors vary from 800 to 1600 feet; and the elevations 10 to 20 miles beyond these—Ingleboro, The Whernsides, Penyghent, Pendle Hill—attain to from 1800 to even over 2400 feet. These mountains and moors fill in the quarter of the compass from S.W. to N.W., and, intercepting the path of rain-laden clouds, and receiving their burden of moisture, form to the district east of them a rain-protecting area; hence the damp westerly winds, after traversing 30 or 40 miles of higher and more extensive moorland than belongs to the westward of most localities in England, reach Harrogate bereft of much of their moisture; a position confirmed by meteorological statistics, which show conclusively a much heavier rain-fall on the western, compared with that on the eastern portion of the highlands of the West Riding.

Average Annual Rain-fall from 1868 *to* '79 *(inclusive.) (Calculated from Symons' "British Rain-fall").*

	Inches.	The number of days on which rain fell ($\frac{1}{100}$ In. or more).
1. Rain-guage Stations within 35 miles West of Harrogate*	50	190
2. Harrogate	33	156
Excess in the West...	17	34

* *i.e.* Clitheroe (altitude 217), Skipton (430-470), Crosshills (405),

These figures show that over 50 per cent. more rain —equivalent to an annual excess of nearly 400,000 gal. or over 1,700 tons per acre—descends on the country to the westward than on Harrogate itself, and the latter is likewise favoured in having annually nearly 22 per cent. fewer rainy days. This increased and more continuous rain-fall to the west of Harrogate is, however, but an apt illustration—perhaps more emphatic than can be adduced elsewhere—of the general fact known to all meteorologists, *i.e.*, the high westward rain-fall, and the much lower eastward one in these Islands. "Now the watery vapour in the air that rises from the heated water of the Gulf Stream is carried to the British Coast by the prevalent west and south-west winds, and is partly intercepted on its passage eastward by the mountains which rise to the west of Ireland and Great Britain. Everyone who has visited Cumberland and Wales knows how rainy these regions are compared with the centre and east of England. The reason is, that the air, laden with moisture from the Atlantic, rises with the winds against the western flanks of the mountains into the colder regions of the atmosphere,

Silsden (560), Barden (746), Cringle (760), Malham Tarn (1296), Otterburn-in-Craven (510), Thornton-in-Craven (456), Slaidburn (475), Settle (623), Arncliffe (750) and Wharfdale (1350).

and the air also expanding at these heights, rain is precipitated there and upon adjacent lands. The same is the case in Scotland, where the Highland mountains on the west produce a like effect; and thus, partly because it is the first land that the wind laden with moisture reaches, and partly because of the mountains, it happens, that a greater amount of rain is precipitated in the western than in the eastern parts of our island."*

For two-thirds of the year Harrogate enjoys from the S.W., W., and N.W., pure mountain air derived from altitudes greater than its own, and furthermore, an atmosphere drier than belongs to these mountains of the west. To the eastward the winds are somewhat broken by the Cleveland and Hambleton hills and the Wolds, and they are robbed of some of their harshness by traversing the intervening vales of Mowbray and York.

Thus, in a general way, the main peculiarities of the climate may be ascribed to the geographical position of Harrogate—high and midway between the seas—and the conformation of the country east and west of it; physical conditions which enable it to receive on the one hand the prevailing westerly

* *The Physical Geology and Geography of Great Britain, etc.*, by A. C. Ramsay, LL.D., F.R.S., etc., Lond., 1878.

winds after traversing a high and extensive mountainous region on which much of their moisture is precipitated, and on the other the modified sea air of the east.

Local Conditions.

The more general features of the climate derived mainly from the geographical position of Harrogate, are modified by physical causes pertaining to the district in which it is placed; such as the following:

1. *The Absence of Forests.*

Meteorologists are pretty well agreed as to the influence of forests in determining a damp and rainy state of the atmosphere; a position proved by the revolutionizing effect of forest-clearing on the climate of well-wooded countries and districts:—the air highly charged with moisture, and ever and anon condensing into rain, becoming dry and discharging its burden of vapour in tropical-like showers at long intervals. The dampness of the atmosphere in the neighbourhood of forests, and the frequent and increased rain-fall, are to be ascribed to the retention of moisture in the soil—trees retarding the natural

draining away of water—and the constant evolution of it from the leaves.

Forest-clearing in all cases is well known to reduce the moisture of the surface soil, and thereby contribute to dryness of the atmosphere. It is believed this result is mainly brought about by the vastly increased evaporation which follows the removal of trees. That there is a marked difference between this process in the 'open' and in a tree-covered area has been proved by experiment. Mr. Blou, F.M.S., at Wynbery Hill, South Africa, sunk in the ground to the depth of four inches, two cylindrical jars of the same size, and each containing 20 oz. of water; placing one in the soil partially protected, but not covered by bush, and the other in a newly cleared plot of ground measuring about 60 ft. in diameter, surrounded by sugar bushes, and otherwise protected from the prevailing wind by a belt of pine trees about 120 ft. distant; in five days the water was carefully measured, and it was found the loss by evaporation from the jar which had been placed in the cleared ground was more than double that from the jar in the bush, or as 1·854 in. is to ·8632 in.; the experiment was repeated with similar results.*

* *Symonds' Monthly Meteorological Magazine*, 1877.

If such a remarkable difference in surface evaporation can be noted in the limited conditions of such an experiment as this, surely we may reasonably infer it to be even more striking, could we gauge the rapid drying of the surface soil of a large open like that of the Harrogate upland, with the retarded process of evaporation in wooden districts where a constant store of moisture is retained.

Harrogate and the country for many miles around are by no means tree-less; but while the timber is sufficient to beautify the district, it is nowhere so excessive or aggregated into such dense masses of foliage, as to attract rain-laden clouds, or to induce a damp atmosphere in their neighbourhood. In days long past the Forest of Knaresbro' was worthy of the name; "this place and the forest, were formerly so thick with wood, that he was thought a cunning fellow that could readily find out those *Spaws*;"* at that time, the climate was probably far different from the present one—doubtless it was damp and raw, and perhaps a generator of disease rather than the health-giving agent it is now. The atmosphere of Harrogate must have gained considerably in dryness by the levelling of this dense forest.

* *The History of the Mineral Waters of Derbyshire, Lincolnshire, and Yorkshire, etc.*, by Thomas Short, M.D., 1734.

2. *The Absence of Rivers or of large bodies of Water.*

The atmosphere of Harrogate is also believed to gain in dryness from the absence of large river-beds and lakes for a considerable distance around it.

From Harrogate the westward strike of the compass is crossed by the Wharfe at a point 14 miles distant, and southward 6 miles: and the Nidd is distant from it 2 to 3 miles northward and 4 to 5 miles eastward. River beds,—often also thickly belted with luxuriant foliage—are known to attract rain and thunder storms, and to condense the vapour in their immediate neighbourhood; they therefore conduce to a moist atmosphere and frequent rains. A common illustration of this is frequently witnessed when thunder or rain storms in the west heavily threaten Harrogate, but nevertheless avoid it by traversing either the course of the Nidd or the Wharfe or by splitting and taking the tracks of both streams.*

* The local distribution of clouds as determined by terrestrial conditions, such as river-beds and forests, has a practical bearing not merely on rain-fall, but on the supply of sunshine:—one of the greatest sources of vigour and good health provided by nature, and of chiefest value to the young, the aged, and to those whose blood and tissues generally are ill-nourished and whose reserve stock of energy

Thus it is, that rain-laden clouds from westerly points of the compass are frequently led towards Knaresborough and the Vale of York, and leave Harrogate dry.

3. *The Configuration of the Country.*

The conformation of the upland on which Harrogate is built and of the district around it is peculiarly favourable to a free circulation of air from all points of the compass. There are no abrupt sheltering barriers to still down the air near the fine piece of undulating table-land, the Stray; around which the houses are scattered in all directions.

Whatever advantages the air acquires from motion are here secured, for—as at the sea side—it is rarely at rest beyond short periods, even when lowlands are close and sultry. Stillness of the atmosphere is an evil. Stagnant air, like stagnant water, becomes unwholesome. Vitality of the atmospheric ocean is maintained—as is the purity of the sea—by the continuous motion of its particles. There-

is exhausted. A plentiful supply of sun-light must be included among the natural remedial agents of Harrogate, for during summer and autumn especially, it has always seemed to the author to be more sun-favoured than other country districts, and—as every health resort should be—than large towns.

fore, whatever breaks up the play of the forces which keep the air in motion, is detrimental to health; such as confined rows of houses, high mountains, or thick belts of trees affording too great shelter from winds, and indoor life, however spacious, and even well ventilated the rooms;* an atmosphere in such situations is apt rapidly to lose freshness, to fail to invigorate, and even to depress, and, whether dry or moist, to become relaxing.

This quality, "freshness," is one which cannot be gauged altogether by chemical tests, or by instruments; it is, however, readily recognised by that

* The writer cannot forbear to quote the following illustrative passages from that invaluable contribution to chemical climatology, —"Air and Rain," by Dr. R. Angus Smith.

"Even very slight elevations sensibly affect the flow of air, and therefore the ventilation and climate of a place.....most of the close places in this country are made by art, although some are made by nature. The worst in the natural class are partly in the power of man; they are narrow glens with close woods. Devonshire has many such examples. The houses seem to nestle comfortably in them, but, as we may believe, with a loss to the inhabitants of some vigour. Even in some very narrow glens in the highlands of Scotland, where one would expect abundant rain and wind to cause sufficient mixture, I am informed that it is common for those who stay at the house, to loss their health, while those who go out among the sheep do not suffer. The state of the houses does not appear to be the cause, as these are no worse these than in better ventilated glens.

most sensitive of all meteorological tests—the human organism;

"But here I feel amends;
The breath of heaven fresh blowing, pure and sweet."

It is specially generated when pure air is set in motion; as when winds prevail, or when breezes frequently strike up; or when subjected to electrical discharges, as during thunder-storms. Some are inclined to ascribe it to the presence in more than ordinary quantity of that active oxidizer—ozone. Whether this be the proximate cause or not, experiments teach us that oxygen, when at rest, and, notwithstanding the removal of the products of respiration, may lose its property of sustaining animal life, but may acquire it again on receiving the molecular motion of an electrical discharge. "In some researches I conducted on the inhalation of oxygen gas, I observed that if an animal were made simply to breathe an atmosphere of pure oxygen gas, al-

.....It would appear, then, that the surface affects the air in more than one way by obstruction of its movements, which causes floating particles to be exchanged, and by sending out organic substances into the atmosphere, hurtful, perhaps, of themselves, and also when decaying.....Climate is affected by that which is on the ground, by the action of the porous ground, by the shape of the ground, and by the quality of the ground. Our climate is not all brought from distant places by the winds."

though the oxygen were perfectly cleared of the products of the combustion of the animal, it would not sustain life, but would allow the animal to fall into a somnolent condition, and to die. But if electrical discharge were passed at intervals through the oxygen, or if it were kept at a temperature above 75° F., it would continue to sustain life. In another series of experiments, I learned that if oxygen were freshly made, and passed in the fresh state through a chamber in which living animals were placed, the animals would continue to live. But if the oxygen that had swept through the chamber, although it were thoroughly purified of animal products, and although it still appeared to be absolutely pure oxygen, were used again, it failed to sustain life until it was subjected to the action of the electric spark, when it regained its activity. I infer from these observations that oxygen may exist in the atmosphere in an inactive condition, not inducing necessarily acute disease, but depression of mind, langour, torpidity, and cachectic feebleness of body."*

Freshness of the atmosphere is probably a condition not merely derived from the removal of im-

* *Diseases of Modern Life*, by B. W. Richardson, M.D., M.A., F.R.S., etc. 1876.

purities, but from this *plus* the presence of oxygen possessing oxydizing power—a property which it may derive from molecular or atomic motion, be it electric, thermic, or mechanical. From this standpoint one cause of the remarkable invigorating quality of the air of Harrogate is obvious; for the absence of any barrier to the winds from all points of the compass for many miles around, and the swelling rather than abruptly rising conformation of the country are conditions which must favour a continuous circulation and agitation of the atmosphere—an incessant unrest over sweeping hills and open dales, and from one grassy and heathery moor to another, whence oxygen may derive intense atomic activity.

4. *The Geological Structure of the District, and the Arrangement of the Formations.*

Dryness of the soil and of the atmosphere is aided by yet another cause; and one perhaps more powerful than the preceding, for it secures the rapid shedding off of rain, and the constant draining away of moisture from the ground on which Harrogate is built. The successive beds of Millstone grit which flank the upland of Harrogate form mas-

sive outer walls which slope away northward and southward at high angles, and enclose within them strata of shale and cherty limestone, which conform to the same general plan, only in a more pronounced way, being still more highly inclined. Wherever the observer turns he cannot detect a piece of undisturbed bedding—the rocks and shales being everywhere tilted from the horizontal. Even the stray—though called table-land—is broken up by undulations which, to the eye of the geologist, mark out a resisting skeleton of rock which denudation has failed to pare down, and the scooping away of the softer formations—the shale. The anatomy of the district could not, therefore, be more favourable to natural drainage.

The reader will readily conceive how different must be the water-charged soil of districts, generally low lying, under which impervious rocks are bedded in horizontal layers:—large tracts of country, unless artificially drained to an unusual degree, constantly exhaling moisture into the atmosphere.

All the foregoing considerations are so many physical reasons which establish beyond doubt the commonly accepted and easily recognised qualities of the air of Harrogate; they all converge in bearing testimony to its great purity and dryness, and to its

bracing and oxidizing powers, from which doubtless spring its health-restoring virtues.

5. *Meteorological evidence of the dryness of the air of Harrogate.*

The humidity of any locality cannot be inferred from the *annual* rain-fall; for the latter may be large, while the rain-fall periods being longer, the atmosphere may be drier than in other places in which a smaller annual rain-fall is less intermittent, and is therefore more evenly distributed throughout the year. The *daily* record of rain is a more sensitive index of atmospheric moisture than the yearly or even monthly totals of the depth of rain in inches; and it is more trustworthy than the use of hygrometers, which merely indicate the amount of humidity in the air at the moment when the daily observation is made, and which, unless skilfully managed, are apt to give inaccurate results. The annual number of rainy days is, therefore, a more important indication of the humidity of the atmosphere than the actual yearly rain-fall; for it may be accepted as a general meteorological truism, that *cœteris paribus* the more intermittent the descent of rain, the less the liability to a continuous surcharge of water in the surface soil, and the smaller the exhalation of moisture into the atmosphere, and *vice versâ*.

The rain-fall statistics of the twelve years from 1868 to 1879 show, that throughout the year Harrogate is more rain-free than other inland watering-places in this country—for it claims the lowest annual number of days on which rain descends.

Inland Watering-places.

The Average Annual Rain-fall and Number of days on which $\frac{1}{100}$ in. or more of Rain fell.

(Calculated from Symons's British Rain-fall from 1868 *to* 1879*—inclusive).*

	Inches.	Rainy days.	Observers.
Harrogate	33·4	156	Coupland.
Bath	33·2	180	Weston.
Buxton	54·7	211	Sykes.
Cheltenham	31·3	165	Humphries, Kay.
Clifton	35·3	174	North, Burder.
Great Malvern ...	31·7	173	Burrow, Sandoe.
Ilkley	41·3	196	Scott, Middleton, Dymond.
Leamington ...	27·1	169	Jones, Barnitt.
Matlock Bath ...	39·0	185	Chadwick.
Tunbridge Wells...	32·6	165	Stow, Miller, Brentnall, Townhend.
Average	36·2	179	

The dryness of the air of Harrogate is proved by the small yearly aggregate of the daily rain-falls. In this respect it excells even Scarborough, of which Dr. Cornelius Fox remarked in 1867, "on making

an examination of the rain records of other health-resorts, it becomes evident that the majority have a greater number of rainy days than Scarborough."* For in 1868, 1869, 1870, 1871, 1872 and 1873 the average annual proportion of wet days in the latter watering-place was 184·8 (data furnished by Dr. Fox in Symons's British Rain-fall) while that of Harrogate was 147·6; and in the twelve years—from 1868 to 1879—rain fell in each average year on 178 days at Scarborough, and on 156 days at Harrogate. But Scarborough is not the only sea-side health resort having more frequent rains than Harrogate. See the following table).

The rain-fall statistics of the twelve years from 1868 to 1879 show, that only two of the leading British health-resorts—Margate and Dover—were favoured by even fewer wet days than annually fell to the lot of Harrogate.

* *Meteorological Observations on the Humidity of the Air of Scarbro'* etc. by Cornelius B. Fox, M.D.

Coast Watering Places.

The average annual number of days on which $\frac{1}{100}$ in. or more rain fell.

(Calculated from data furnished by Symons's British Rainfall).

	Wet Days.	Periods of Observation.	Observers.
Bournemouth	163	1868 to 1874†	Newnham, Compton.
Brighton ...	167	1870 to 1879†	Sawyer.
Eastbourne ...	174	ditto	Hall.
Grange	182	1872 to 1879†	Beardsley, Massie.
Hastings ...	167	1870 to 1879	Lewis.
Ilfracombe ...	182	ditto	Clark, Weston.
Llandudno ...	178	ditto	Nicol.
Penzance ...	244	1873 to 1879†	Trelawny.
Sidmouth ...	176	1870 to 1879	Radford.
Southport ...	192	1872 to 1879	Braxendell.
Torquay ...	190	1868 to 1879†	Pengelly.
Ventnor ...	160	1870 to 1879	Ryde, Martin.
Whitby... ...	189	ditto	Simpson.
Average	181	Harrogate (corresponding periods)	158

† During these years the average annual number of rainy days in Harrogate were 149 ('68 to '74), 157 ('70 to '79), 169 ('72 to '79), 163 ('73 to '79) and 156 ('68 to '79).

CHAPTER II.

MEDICAL EXPERIENCE OF THE CLIMATE.

INASMUCH as Harrogate—apart from its medical springs—has acquired a steadily growing reputation as a health-resort, some notice of the medical aspects of its climate appears to be called for. These may be conveniently reviewed under two heads; the salubrity of Harrogate for residents and for the majority of visitors; and the climate in its more specially medical applications to invalids.

THE SALUBRITY OF THE CLIMATE.

The healthfulness of Harrogate, either for those who adopt it as their permanent residence, or who resort to it for limited periods, is abundantly proved by the following considerations.

1. *Harrogate as a resort for permanent residence.*

For more than twenty years past Harrogate has attracted an increasing number of strangers as permanent residents. The writer—who has had extensive opportunities of observing the effects of the climate on the health of this class—has generally

seen the happiest results follow the migration. Even when before venturing on this step, apprehensions have been entertained lest the cold months at Harrogate should prove too keen, experience has generally shown their groundlessness; and even that which was most feared, has, as a rule, become the source of firmer health. The highly bracing quality of the air of Harrogate, especially in the winter months is one of the strongest recommendations of the climate to outsiders. Much of the general debility produced by the depressing influence of town-life and other causes may be fostered and intensified by resorting more and more to protecting influences, such as those of mild or sheltered climates; while the remedies frequently required, though often shunned or feared, are such as provoke the healthful generation of new force and develope the power of resistance by testing it. Hence doubtless the value of the climate of Harrogate mainly consists in its powerful tonic quality, which soon declares itself in improved appetite, and more vigorous digestion and nutrition, and greater resistance to meteorological and other influences. It is soon discovered that the dreaded coldness of Harrogate in winter differs greatly from that of low-lying and generally damp districts, and of the less invigorating atmosphere of

towns—for the air being drier and more oxidizing generates an increased warmth which counteracts the chilling effects of cold; and furthermore, this greater combustion within the system incites to the ingestion of more fuel as food. Thus, providing there is a sufficient substratum of vigour and no exhausting organic disease, lowness of temperature in an atmosphere of this type no longer depresses, as a cold moist air is apt to do, but stimulates the whole round of the functions involved in nutrition, whereby the health becomes more vigorous and consolidated. Many of those who are settled in Harrogate were led to it chiefly because a temporary sojourn either relieved or cured an ailment or some defect of health which persisted elsewhere, and the wisdom of their choice has been confirmed, as a rule, by further experience of the climate. And there are others who less or more ailing or weakly, but without definite disease, and attracted to the place by its well-known character for healthfulness, are satisfied with the improved vigour which Harrogate has brought them.

2. *Harrogate as an Educational centre.*

For many years past Harrogate has been steadily growing in popularity as a locality well adapted for scholastic purposes; a popularity founded on its

salubrious climate more especially for the young. It has now become a large and important educational centre, possessing at least twenty-six boarding schools, while twenty-five years ago there were but two. The repute of the climate and waters often induces parents to send delicate children to these establishments; according to the writer's ample experience of these cases he can speak confidently of the almost invariable benefit derived from their sojourn in Harrogate; and futhermore, he must bear witness to the high standard of health maintained in all the schools.

3. *The Mortality.*

The annual death-rate is undoubtedly much below that of other watering-places, for in 1877, 1878, 1879 and 1880 it was, among residents, only 12·1, 12.6, 14.4 and 14.5 respectively per 1000, estimating the population at 9,500 as determined by the census returns of 1881.

The deaths of visitors cannot fairly be included with those of residents, for visitors to Harrogate are as a class more ailing than such as resort to seaside and other watering-places mainly for recreation, and they swell up the permanent population to more than double; while this excess of population cannot

be accurately known, and therefore fails to be estimated in the returns. However, even inclusive of visitors, the death-rate of Harrogate compares favorably with that of other watering-places, *e.g.* in 1880 it was only 16·5 per 1000.

4. *The Amount of Sickness.*

The prevalence of sickness as a test of salubrity, in the absence of definite statistical data, can only be correctly estimated by those continually conversant with it. The resident medical men believe it to be decidedly below the average, the character of the population duly considered. Certain diseases, *e.g.*, consumption, rheumatic fever, typhoid fever, are rare; and those, such as pneumonia and bronchitis, the prevalence of which ought to be anticipated from the nature of the climate in the cold months, are certainly not more frequently met with than in more protected districts, perhaps much less so. The climate undoubtedly corroborates the general health: may not this influence, assisted by the characteristic dryness of the air, thwart the ordinary action of cold on the system in setting up acute inflammatory attacks?

5. *The Domestic Water Supply.*

The essentials of a good water supply are—

1. Purity and freedom from the possibility of contamination (organic or metallic).

2. An abundant and uninterrupted supply at all seasons.

3. A low degree of hardness.

All these conditions are pre-eminently met by the water supplied by the Harrogate Water Works Company.

1. *Purity.*—The writer has carefully inspected the sources which feed the several reservoirs, at Haverah Park, Beaver Dyke, and those near Harrogate; they are far away from dwellings and the possibility of receiving impurities of any kind. The spring at Haverah Park gushes from the side of a rocky hill, and the source at Beaver Dyke is derived from the rain filtering from the Grit Moors—one of the purest of water-sheds. (See table p. 30).

2. *The supply* has never been known to fail, notwithstanding the enormously increased demand created by every season—when the population is more than doubled and continued droughts most apt to occur. It is a constant supply, as distinguished from the intermittent one to which water companies are sometimes from scarcity of water compelled to resort.

The reserve capacity of the reservoirs is no less than 81 millions of gallons; but when the Beaver Dyke reservoir is completed, it will be increased two-fold.

3. *Hardness.*—Among other water supplies, that of Harrogate is remarkable for the small quantity of solid matter held in solution, and for its softness. Its high position in these respects among waters supplied to other health resorts is indicated by the following table, drawn up from data furnished by the Report of the Rivers Pollution Commission, "Domestic Water Supply of Great Britain, 1874."

Waters supplied to health-resorts.

Results of analysis, expressed in grs. per gal.

Town.	Total solids.	Hardness.	Previous Sewage or Animal Contamination.	Formations whence Derived.
Harrogate	5·53	2·94	0	Millstone Grit.
Bath	22·16	17·64	4·917	Lias and Oolite.
Buxton	6·28	3·08	0	Yoredale Grit.
Brighton	21·92	14 94	7 845	Chalk.
Cheltenham ...	14 85	10·57	2 730	Upper Lias.
Clifton	19·56	17·22	1·525	New Red Conglomerate and Mountain Limestone.
Eastbourne ...	30·18	14·63	1·010	Lower Greensand.
Ilkley	7·99	6·02	0	Millstone Grit.
Leamington ...	48·24	19·25	1·590	New Red Sandstone.
Malvern	5·57	3·18	1·275	Granite and Gneiss.
St. Leonards ...	20·80	16·94	1·190	Lower Greensand.
Scarborough ...	25·29	15·05	2 745	Coralline Oolite.
Tunbridge Wells	8·58	2 31	4·640	Lower Greensand.
Average	19·28	11·65	2·455	

One feeder (Haverah Park Spring) contains but 4 grains of solid residuum per gal:—a quantity almost identical with that of the celebrated Loch Katrine (3·92).*

These qualities of the water are determined by the geological structure of the collecting area; made up as it is of massive beds of Millstone grit and shales, which, like all other gritty or sandy and argillaceous or slaty strata, contain but little soluble matter, which can be washed out by rain. How different the water which has percolated over or through calcareous formations, such as the Chalk, Oolites, Lias, Limestone (Carboniferous or Permian) and Gysiferous New Red sandstone; then, as with many instances in the foregoing table, the load of earthy salts is declared by excessive hardness.

6. *The Sewerage, etc.*

Within recent years, Harrogate has been provided with a costly system of sewerage, which, in every detail, has given great satisfaction; it is constructed on the irrigation principle, of which it is one of the most successful examples in this country, and may be regarded as a model of this form of the utilization of sewage.

* The analysis of Oct. 14th, 1873. *Water Supply of Great Britain*, 1874, p. 347.

The sanitary condition of Harrogate will compare favourably with that of any other watering-place in this country, and by far excels that of most Continental spas; this fact is attested by the rarity of epidemics. No one can fail to recognise the public zeal of those in authority—though abused beyond measure when in office—and of others alive to the fact that Harrogate is more richly endowed by the hand of nature than its fellow resorts, to maintain by every available means its healthfulness, and thereby to preserve unimpaired its acquired reputation as a mineral watering place.

The Climate for Invalids.

Observation of the effects of the climate of Harrogate suggests, however, certain indications and contradictions, which, as with any climate of decided effect in special directions, should serve on the one hand, as guides to the selection of cases best adapted to its beneficial influence, and on the other as warnings to exclude others. Of these the writer can but give a mere outline sketch, which may, nevertheless, be more useful as a chart without the heavy shading in of many details.

1. *Indications.*

While marking out some of the special morbid conditions which observation leads the writer to view

as more than others likely to benefit from the climate of Harrogate, only that experience is here formulated which appears to him to be most worthy of attention.

1. *Relaxation and debility of tissue*: whether occurring as a general condition affecting less or more all the organs of the body, or as a more special and local affection of certain structures; such as:

(a) The debility arising from town-life, and the loss of tone induced by sedentary employment; exhaustion from overwork, or from work continued on from year to year without reprieve, until the sources of reserve force are partially used up by a continued expenditure which has exceeded the income, so that now there is but a limited balance left; the tissue-exhaustion of protracted convalescence, or that which arises from a prolonged drain by purulent or other discharges, etc.

(b) Some local debility in advance of a general loss of tone—*e.g.*, relaxed and debilitated conditions of the skin; flabby and toneless mucous membranes, atonic dyspepsia, atony of the bronchial mucous membrane, relaxation of the pharynx. The writer has frequently observed the curative power of the climate of Harrogate over a liability to bronchitis, in which, conjointed to a loss of tone generally, there

appeared to be a specially relaxed bronchial mucous membrane; a condition which warm climates—especially when moist—may fail to cure, but which is met by building up and bracing influences.

2. *Scrofula*, whether with or without local manifestations, is a morbid condition to which the treatment of Harrogate is specially adapted, both by virtue of the tonic climate, as well as by the medicinal springs of established reputation as anti-scrofulous agents. Though strumous cases, like others, usually resort to Harrogate during the season, the writer holds they would derive still more benefit by a course of treatment extended through the winter months. Harrogate possessing curative advantages of exceptional power over all forms of malnutrition in the young, as well as ample choice of high-class schools for both sexes, offers rare hygienic as well as educational benefits to children in whom the nutritive and developmental processes are sluggish or defective.

3. *Nervous debility and prostration from mental over-strain*, when not attended by excessive nervous irritability and sleeplessness.

4. *Anæmia and chlorosis.* The dry oxidizing air is undoubtedly a valuable auxiliary to the operation of the powerful ferruginous springs in blood-building.

The treatment of these cases is sometimes even more effective in the cold months.

5. *Degenerative changes in the elderly.* The writer has repeatedly noticed a marked improvement in the health of those who, previous to resorting to Harrogate, appeared to be declining prematurely; this and other similar experience incline him to regard it as one of the healthiest of localities for the aged.

6. *Heart diseases etc.* The level walks in and about High Harrogate where the tonic properties of the climate may be enjoyed with less physical exertion than in hilly watering places, conduce greatly to the comfort and progress of cardiac and other cases in which locomotion is difficult or impaired.

7. *Some cases of chronic phthisis* may resort to Harrogate during the warm months with great benefit; such, for instance, as require, after spending the winter in the south of France or elsewhere, a dry bracing climate during the summer and autumn; and in which the clinical features are—absence of febrile movement, the local disease quiescent, or taking a favourable course, digestive organs toneless with liability to disturbances of the liver, and signs of a strumous diathesis combined with the tubucular.

2. *Contra-Indications.*

Though nearly all those who resort to Harrogate either for limited periods or for permanent residence are invigorated thereby, the writer must state the few conditions—exceptional though they be—which have appeared to him to contra-indicate the climate, *especially during the cold months.*

1. *Chronic pulmonary disease* characterized by the signs of a tubercular rather than of a strumous diathesis; by febrile disturbance; by progressive wasting; by advancing and advanced local disease.

2. *Progressive organic disease* exhausting the digestive power, and impairing assimilation.

3. *Irritability of the mucous membranes,* such as a dry hypersensitive condition of the larynx; irritable bronchial and nasal mucous membranes; great susceptibility to gastric catarrh, and irritability of the stomach.

4. *A highly sensitive and irritable state of the nervous system.* The climate of Harrogate is apt to be exciting—over stimulating—in certain forms of nervous debility, marked by excessive irritability; a condition sometimes associated with an irritable state of the gastric mucous membrane and sleeplessness.

CHAPTER III.

THE CLIMATE IN CONJUNCTION WITH THE MINERAL WATERS.

VIEWED in conjunction with the prescribed courses of the waters, the climate is found to be of exceptional medical value.

The operation of the various springs may be epitomized as depurant or tonic, or some combination of these therapeutic actions. Medical practice aims at conserving the powers of the system, even when it is found depuration is most needed, and prefers a conjunction of restorative agencies whenever the aim is to tone and reconstruct. Hence, from whichever side the curative powers of the waters are approached, the invigorating property of the climate must be construed as a powerful auxiliary. This fitting combination becomes all the more noteworthy when it is found that other medicinal springs of similar constitution and virtues elsewhere are, as a rule, associated with climatic conditions less favourable to their therapeutic aims. Other watering-places at home may be dismissed from consideration, inasmuch as the climate of none can approach that of

Harrogate in freshness, dryness, and invigorating properties; and of the foreign springs, those who have visited such of them as resemble the Harrogate waters, must admit that they are situate for the most part in mild, moist districts: Homburg appearing to be the sole exception.

Besides the immediate advantages which visitors to Harrogate derive from the tonic climate while undergoing the prescribed courses of waters, they avoid, as a rule, even when restricted throughout to the aperient and diuretic waters, the debility apt to ensue from depurant treatment, followed up in watering-places possessing a warm moist atmosphere or a less bracing climate; an exhaustion, for the removal of which a bracing mountain or sea-air is often sought. A recruiting visit after the Harrogate treatment is, however, generally unnecessary, for it is usually found that the restorative process has kept pace with, or even outstepped the depurating action.

Furthermore, the writer believes the tonic properties of the climate is one reason* why many visitors are enabled to undergo longer treatment by the evacuant waters than they could do without injury in a moist relaxing atmosphere. He has frequently

* Doubtless others may be also assigned, such as the *sui generis* constitution of the waters, and their special suitability to cases.

been surprised at the remarkable duration—even months without interruption—to which, for instance, a course of the Old Sulphur spring may be extended; the patients the while gaining in weight and strength, and their ailments quietly and steadily dispersing.

Besides the climate, another auxiliary to the curative operation of the medicinal waters should not be overlooked; namely, THE WATER SUPPLY. The value of pure soft water in this connection will be illustrated more forcibly by briefly reviewing the deleterious effects of hard water.

1. Drinking-water highly charged with earthy salts (especially calcium sulphates) is frequently injurious to the dyspeptic, the constipated, the gouty, and to those whose renal function is precarious, and furthermore, to the aged, in whom calcareous degeneration of the arteries, besides failure in all the processes of elimination, are progressing.

To these, and in fact to all other visitors to Harrogate, the town water is most grateful, as well as a valuable hygienic aid to the operation of the medicinal springs.

2. Daily ablution in hard water is apt to injure the skin, and to obstruct its functions. The fats and volatile fatty acids of the perspiration and sebaceous secretion may form—as soap does--in-

soluble compounds with lime, which may readily block up the oil and sweat glands, and harden the epidermis. The injurious effect may with delicate skins go beyond this stage, and, reminding one of the inflammatory œdema in the portions of the skin long varnished in Edenhuizen's experiments, may set up forms of eczema, which, once established, may be perpetuated by the further use of hard water. Ablution in hard water is unquestionably injurious to inflammatory skin diseases; hence one of the softest and purest waters of Britain must be a boon to the thousands of cutaneous cases which are annually attracted to Harrogate.

THE

HARROGATE WATERS.

CHEMICAL DATA.

"For art may, but nature cannot miss."—DRYDEN.

INTRODUCTORY.

1. *The number of medicinal springs.*

"A place that may justly challenge Britain and perhaps all Europe for its great numbers and variety of mineral waters." So wrote Dr. Thomas Short in 1734 while introducing Harrogate to the notice of the medical and scientific world;* a remark, however, even then more than 100 years old; for in 1632 it was thus penned in rather similar terms by Dr. Stanhope, one of the earliest writers on the medical virtues of the Harrogate waters. "Our spaw can in justice yield to none in England for the great consequence and variety of its springs, there being a great many sorts within two miles of one another. Had they but one year such an ingenious examiner as Dr. Jordan, we might expect nations to

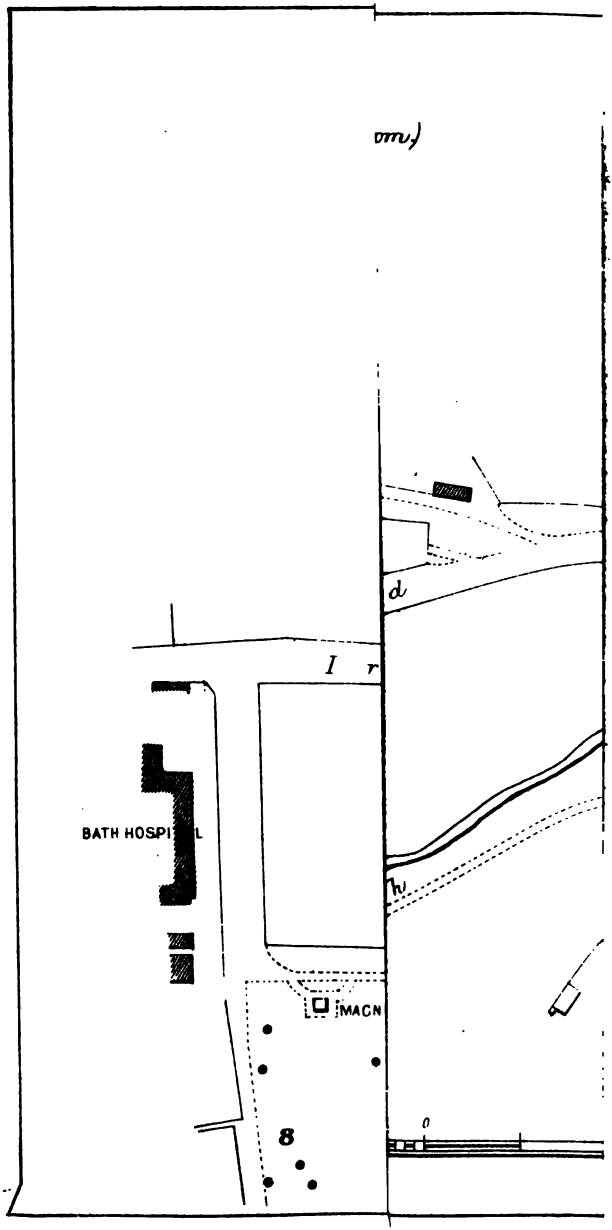
* "The natural, experimental, and medicinal history of the mineral waters of Derbyshire, Lincolnshire, and Yorkshire, etc.," by Thomas Short, M.D. Sheffield, 1734. Published by request of the Council of the Royal Society.

flock to them."* These statements may appear to us somewhat ambitious when we note the small number of different springs in use in the time of Stanhope—only six†—and in that of Short, certainly not more than twelve.‡ But surely we may be permitted with justice and without ostentation to apply similar terms to the Harrogate of to-day, inasmuch as the district embraced by two miles East and West of it possesses no fewer than eighty medicinal springs,

* "Cures without care; or a summons to all such as find little or no help by the use of Physick, to repair to the Northern *Spaw* wherein by many precedents of a few late years, it's proved to the world that infirmities of their own nature desperate, and of long continuance, have received perfect cure by virtue of mineral waters near *Knaresburgh*, in the West Riding of *Yorkshire*," etc., by Michael Stanhope. 1632.

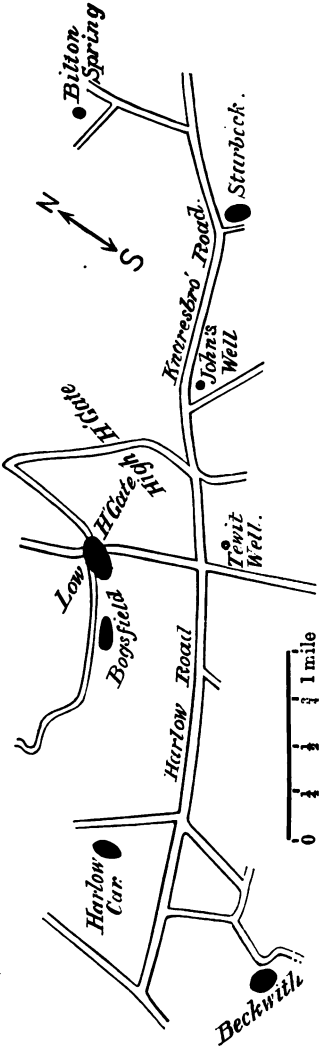
† These were: the Tewit well; three stinking wells, viz., one at Bilton Park, one near Knaresbro' and one at Harrogate (the old Sulphur well); the dropping well of Knaresbourgh. All these springs are mentioned by Dr. Dean in his "*Spandarine Anglica*, or the *English Spaw* Fountain," etc., 1626, the first medical treatise on the Harrogate waters. Stanhope adds the Sweet spaw (or John's well) discovered by him in 1631.

‡ In addition to the foregoing: the alum well in the Bogs-field; two sulphur wells, making three at the Village (Harrogate); the Starbeck chalybeate; the strong hospital sulphur, Begs-field?; and a chalybeate S. W. of the alum well, a chalybeate oozing 100 yards S. E. of the three sulphur wells. Dr. Short also refers to issues of sulphur water "about a mile and quarter West of Harrogate on the brook side" evidently referring to the sulphur-water issues of Harlow Car, inasmuch as he says the "Bogg above the Village" is "a mile east of this."


BATH HOSPI L
MACN

no two of which are alike, and some of them, both from a chemical and from a therapeutic standpoint, unrivalled elsewhere.

The accompanying map will enable the reader to realize a better conception of this incomparably rich store of mineral waters, than can be furnished by a description of their several localities and relative position. It represents the groups of wells on the Bogs-field and in Low Harrogate —localities which are literally studded over with them. Many of them are so clustered together, and they all occupy so small an area, that it is a matter of astonishment to all, how



the medicinal waters which issue into these wells can, year by year, maintain their distinctive qualities.

The sketch plan on the preceding page indicates where mineral waters have been discovered, not merely in Harrogate, but in the district, viz., at Starbeck, Bilton, Harlow Car and Beckwith.

Inasmuch as the last named locality has not hitherto been known to yield medicinal springs, it should be mentioned that numerous issues of sulphur water have been observed by the author in the beds of the Crimple Beck and of the stream which joins it near Hole House; and one of these by the side of the brook near Low House, when isolated from surface water, is found to yield at least nine gallons of beautifully transparent and well aërated sulphur water in the hour; of this spring Mr. Davis kindly furnished the writer with an analysis, which places on record one of the available medical resources of Harrogate hitherto unrecognised.

Specific gravity 1000·56. *Reaction—decidedly alkaline.*

GRAINS IN 20 OZ.

Ca	·321	Calcium sulphate	·072
		Calcium carbonate	·743
Mg	·151	Magnesium carbonate	·52
Na	1·140	Sodium carbonate	2·019
		Sodium chloride	·421
		Sodium hydrosulphide (NaHS)	·241
K	·040	Potassium chloride	·076
SiO_2	·066	Silicic acid	·066
Li, Fe	traces	Lithium chloride, Ferrous sulphide	traces.
Radicles SO_4	·049		
Cl	·293		
CO_3	1·965		
S	·138		
	4·163		4·167

June, 1880.

2. *Temperature of the waters.*

All the Harrogate waters, like those of Homburg, Kissengen, Kreuznach, and some other similar saline springs, are non-thermal. The Sulphur waters, the Kissengen, and the Chloride of Iron are, however, dispensed in thermal doses. These waters are warmed during transit by an ingenious apparatus, the Therma;* circulating through coils of pipe enclosed in a hot-water chamber, they receive heat by conduction, and are served at any temperature, with-

* This improved method of heating the waters supersedes the primitive practice still adopted at many non-thermal spas, such as adding a small quantity of very hot water to the medicinal water, or placing the latter in a vessel of hot water.

out loss of gases or precipitation of dissolved constituents. In some respects this arrangement surpasses even the conditions of thermal waters; for, it enables the temperature to be adjusted to the requirements of cases, and, moreover, it avoids the waste of gas (notably sulphide) during the requisite cooling of too hot waters, as at Aix-la-Chapelle, Burtschied, Toplitz, Luchon, and other thermal sulphur springs of unnecessarily high temperature.

Inasmuch as heat, whether natural or added, is the same force, the waters thus warmed by conduction in enclosed tubes become essentially thermal, and the importance of this quality in conjunction with strong charges of saline matter—as in these waters—comes out the more when it is remembered that all naturally thermal waters (and especially those exceeding 90° F.) are poor in solids, and that a high temperature is required for the rapid absorption of salines, especially chlorides in concentrated solution: nature, however, keeps apart hot water and water well charged with salts.

3. *The continuity and constancy of mineralization.*

The continuous outflow of waters charged with various solid and gaseous constituents, in much the same proportions year by year for even centuries,

is a matter of interest and astonishment, even to the scientist conversant with the processes of nature.

This constant washing out of the soluble portions of the strata traversed by the waters furnishes a large yearly output of salts: and this must be specially the case in a district like that of Harrogate with its remarkably numerous issues of mineral springs. Two examples will suffice to illustrate the busy mining operation of water in mineralizing the various issues.

The OLD SULPHUR SPRING, in its continual overflow of 12½ gallons in the hour, is computed to throw off year by year—7 tons of the Chlorides of Sodium, Potassium, Calcium, and Magnesium; 240lbs. of Sulphide of Sodium; 100lbs. of Chloride of Barium; 37lbs. of Iodide and Bromide of Magnesium.

The CHLORIDE OF IRON WELL, estimated to flow at the rate of 12 gallons per hour, delivers annually —3 tons of the Chlorides of Sodium, Potassium, Calcium, and Magnesium; 217lbs. of Protochloride of Iron; 173lbs. of Protocarbonate of Iron; 100lbs. of Chloride of Barium and Strontium; 14lbs. of Chloride of Manganese; 5½lbs. of Bromide of Magnesium.

But, in connection with the mineralization of the springs, the matter of practical importance to medi-

cal men and their patients, is the constancy of it; do the waters steadily maintain, at all times, such a uniformity of composition as not to disturb or impair their trusted therapeutic operations? The constituents of all medicinal springs, whether derived from a large collecting area of rain-fall, or from deep sources, or otherwise, do vary in quantity from day to day, from week to week, and even from year to year; for all the analyses of any well-known spring executed at different times, however carefully, and even by the same chemist, are not alike—they differ beyond the limits allowable for the necessary imperfections in the methods. But all such variations may be traced to physical causes, and are merely of interest to the student of chemico-geology. They have no practical bearing on the treatment of disease —for, though they may be distinctly traced in a large volume of water, they assume minimal therapeutic importance in the smaller quantities prescribed.

The limited space at the disposal of the writer does not enable him to illustrate the constant integrity—*from a therapeutic standpoint*—of all the numerous Harrogate waters in daily use further than by selecting two prominent representative examples: one from the Sulphur, and the other from the Iron

group; and moreover one *a natural issue* of mineral water (the Old Sulphur spring) and the other *a well* (the Chloride of Iron water).

(1) *The Old Sulphur Spring.*

For nearly 300 years this water has persistently maintained its therapeutic powers: and hence the preservation throughout this long period of an unimpaired chemical constitution may be fairly presumed.

The earliest records of its well-known effects are furnished by Dr. Dean in the early part, and by Dr. French in the middle, of the seventeenth century, though they were doubtless recognised towards the close of the sixteenth century, if not before. Dr. Dean refers to its curative powers thus: "Such as drink the water verily believe there is gunpowder in it, and they vomit it up again . . . The common people drink them, and they expel Reef and Fellon."*

And Dr. French, writing on the same theme, observes: "Cold dull bodies can bear more than others: but, in general, let the quantity be such as

* "*Spandarine Anglica*, or the *English Spaw* fountain; being a brief Treatise of the acid, tart Fountain in the Forest of *Knaresburgh* in the West Riding of *Yorkshire*, as also a relation of other Medicinal Waters in the said Forest." *By Edm. Dean*, Doctor in Physick, *Oxon*, dwelling in York; Lond. 1626.

may move the belly five six or seven times, as the body can bear. This water often works too quickly upon several bodies."*

Until the last quarter of the last century there were no reliable data bearing on the chemical constitution of this spring—nor is this surprising considering the imperfect state of chemistry during the last century and that preceding it. Though Dr. Short gives us the total solids in 1734: "A gallon of the upper well (or that commonly drunk) exhaled, left near two ounces of salt,"† and though Dr. Higgins in 1780 obtained a similar, though a somewhat smaller quantity, it was not until 1783, when Dr. Joshua Walker,‡ and 1791 when Dr. Garnett,§ analysed the water with more pretention to accuracy, and attained results comparable with those of subsequent analysts.

The trustworthy chemical history of this spring extends therefore over a period of 100 years, and is

* "*Yorkshire Spaw*, or, a Treatise of four famous Medicinal Wells, *viz.* the *Spaw* or Vitrioline Well; the Stinking or Sulphur Well; the dropping or petrifying Well; and St. Mungo's Well near *Knaresburgh* in *Yorkshire*: together with the causes, virtues, and uses thereof." By *John French*, M.D. 1654.

† *Op. cit.* p. 195.

‡ *An Essay on the Waters of Harrogate and Thorpe-arch.* By Joshua Walker, M.D., Physician to the Leeds Infirmary, 1784.

§ *Treatise on the Mineral Waters of Harrogate.* By T. Garnett, M.D. 1792.

Analyses of the Old Sulphur Well from 1783 *to* 1881.

	Analyst ... . Date	Walker. 1783	West. 1828	Hunter. 1830	Hoffmann. 1853	Muspratt. 1867	Davis. 1872	Thorpe. 1875	Davis. 1879	Davis. 1881
	Temp.	48° F.	...	...	48° 2 F.	...	48° 9 F.	48°·2 F.		
	Sp. gr.	...	1013·24	...	1011·13	...	1011·16	1011·04	1011·60	1011·405
Grs. in imperial gallon.	Lime	...	39·8	43 5	48·243	46·233		38 697		
	Magnesia	...	14 7	18·0	3·446	27·392	(1866)	23·839		
	Baryta	...	...	...	...	3 68	4·719	4·833	4·539	4·670
	Lithia	...	...	...	...	trace	...	0·266		
	Potash	...	...	...	33·869	44·165	...	6·063		
	Ammonia	...	...	...	...	...	...	0·328		
	Soda	...	484·0	471·0	474·054	470·635	...	477·022		
	Chlorine	...	623·9	608·0	650·384	654·908	615·62	613·770	619·611	627·57
	Bromine	...	...	...	trace	trace	...	1·985		
	Iodine	...	...	...	,,	,,	...	0·103		
	Sulphur	...	..	...	6·353	6·737	6·412	6·532		6·460
	Carbon dioxide ...	...	...	...	...	...	...	35·404		
	Silica	...	...	...	0·241	...	...	0·703		
	Sulphuric acid... ...	...	absent	absent	0·101	absent	absent	absent	absent	absent
	Residue on evaporation.....	1111·	1024·8	1016·0	1095·919	1108·781	1046 56	1047·013	1061·720	1048 25
Cub. in.	Free H_2S	...	...	...	0·531	7·01	...	10·16		
	,, CO_2	...	...	...	22·03	25·55	...	40·10		
	Total in cub. in. ...	...	36·4	34 0	36·09					

epitomized in the table on the preceding page—based on that constructed by Prof. Thorpe*—from which we learn the water has preserved the main feature of its constitution throughout the past century with remarkable constancy.

A falling off in mineralization—either in regard to the total contents, or to the sulphur, or to the salines—has not been detected, notwithstanding the unprecedented chemical scrutiny to which the water has been subjected during the past quarter of a century; and, moreover, the local rain-fall and the season fail in disturbing the normal charge of the constituents. (See p. 59).

It may be safely asserted that this spring possesses a constant mineralization—or so constant as not to impair its therapeutic action—not only all the year round, but from year to year, and has probably maintained much the same stability of composition for centuries.

(2) *The Chloride of Iron Water.*

That chapter of the chemical and therapeutic record of this well opened by Professors Muspratt and

* *A Contribution to the History of the Old Sulphur Well, Harrogate.*" By T. E. Thorpe, Ph.D., F.R.S. Professor of Chemistry in the Yorkshire College of Science, Leeds. Philosophical Magazine, July, 1876.

Miller in 1865, has ever since preserved its unity; and the recent painstaking researches of Professor Thorpe show that this remarkable water still maintains unimpaired the integrity of its chemical composition.

Mr. R. Hayton Davis, F.C.S. has tracked the chemical history of the leading constituents during the period from July 1865 to the present time; and he has kindly placed at the writer's disposal all the data collected during his praiseworthy and patient enquiry. The author is therefore enabled to present a valuable and reliable resumé of the chemical variations in the proportions of the principal ingredients —and of these as a whole—which have occurred subsequently to 1865.

Though throughout this long period the *remarkable constitution* of the water has remained intact, the leading constituents have been frequently detected in different quantities both relatively to each other and to their collective amount; but the writer believes the recorded changes are only such as may be discovered in any well into which water as strongly mineralized as this issues, were it subjected to a similar chemical scrutiny over an equally long period of time.

From a medical stand-point, the most satisfactory outcome of these chemical observations is the proven

fact, that whenever changes were detected, they were mainly on the side of increase rather than decrease; for out of 160 analyses, in 102 (or 64 per cent) the Chloride of Iron, the Carbonate of Iron, the total amounts of Iron, of Chlorine, and of solids exceeded the quantities recorded by Prof. Miller in 1865: while in only 58 (or 36 per cent) were they detected below them; and furthermore the average aggregate rise of all these constituents was *nearly double* that of the fall: and the average rise and fall of Iron—one of the most important ingredients—was in the proportion of 14 to 1, and the average increase of Protochloride of Iron exceeded the average decrease by 4 to 1. The observations which recorded maximal and minimal variations emphasize these conclusions still more.

The practical bearing of these facts on the therapeutics of the water is obvious; for they show that, at least the ferrugenous impregnation, and, especially that of chloride of iron, has not only kept faith to its early promise, but in the main has far exceeded it.

The chloride of iron water.

GRAINS IN 20 OZ.

		Protochloride of iron.	Protocarbonate of iron.	Total Iron.	Total Chlorine.	Total Contents.
Miller.						
1865	... ...	1·81	1·45	1.49	35·62	58·18
Davis.						
From 1865 to 1879	average Increase ...	1·21	·08	·42	6·03	7·76
	average Decrease ...	·34	·18	·03	4·14	4·14
Thorpe.						
1880	Increase ...	—	—	—	1·31	1·76
	Decrease ...	·15	·06	·09		—
1881	Increase ..	—	the	—		5·76
	Decrease ...	·07	same	·03		—

It may be noted that changes in the quantities of of constituents, however considerable in a large bulk of water,—*e.g.* a gallon—assume minimal proportions in the small average dose prescribed, *e.g.* four ounces. This fact is demonstrated by the following table.

Grains in 4 oz. (the average dose) of chloride of iron water.

	Protochloride of iron.	Protocarbonate of iron.	Total iron.	Total solids.
Miller's analysis.	·36 ($\frac{4}{11}$)	·29 ($\frac{3}{10}$)	·50 ($\frac{1}{2}$)	13·63
Davis' analysis.				
average { Increase	·24 ($\frac{1}{4}$)	·01 ($\frac{1}{100}$)	·08 ($\frac{1}{12}$)	1·55
average { Decrease	·06 ($\frac{1}{17}$)	·03 ($\frac{1}{33}$)	·006 ($\frac{1}{166}$)	·81
The highest recorded and lowest recorded { Increase ...	·50 ($\frac{1}{2}$)	·05 ($\frac{1}{20}$)	·22 ($\frac{1}{4}$)	2·3
The highest recorded and lowest recorded { Decrease ...	·14 ($\frac{1}{7}$)	·09 ($\frac{1}{11}$)	·08 ($\frac{1}{12}$)	1·35
Thorpe's analysis.				
1880 { Increase	—	—	—	·35
1880 { Decrease	·03 ($\frac{1}{33}$)	·01 ($\frac{1}{100}$)	·01 ($\frac{1}{100}$)	—
1881 { Increase	—	the same	—	1·15
1881 { Decrease	·01 ($\frac{1}{100}$)		·006 ($\frac{1}{170}$)	—

It is sometimes asserted that the consumption of the waters created by the season and an increase of the local rain-fall diminish the mineralization. But the following data* show a remarkable constancy in the impregnation of the Old Sulphur spring and the Chloride of Iron spa throughout the whole year, and the slight variations recorded appear to be independent either of the season or rain-fall.

* *Monthly Analytical Examination of the Harrogate Spas*, 1872. By R. Hayton Davis, F.C.S., Jour. Chemical Soc., Nov., 1873.

Old Sulphur Well.

	Temp. in Well.	Specific Gravity.	Sulphur. (Grains per Imp. Gallon.)	Chlorine. (Grains per Imp. Gallon.)	Total Residue. (Grains per Imp. Gallon.)	Rainfall each month in In:
1872.						
January 31 .		1011·14	6·248	613·49	1029·28	4·50
February 29 .	46°	1011·37	6·344	616·93	1044·25	3·15
March 30 . .	46°	1011·23	6·052	615·62	1042·01	2·31
April 30 . .	47°	1010·34	6·540	614·45	1049·69	3·51
May 31 . . .	48°	1010·83	6·532	603·91	1034·20	1·64
June 29 . .	50°	1011·95	6·592	616·22	1028·43	4·70
July 31 . . .	52°	1011·11	6·300	617·46	1056·26	5·90
August 31 .	52°	1010·84	6·496	612·46	1047·87	4·48
September 30	52°	1010·80	6·800	610·22	1041·14	5·18
October 31 .	50°	1011·42	6 304	619·62	1058·13	5·10
November 30.	48°	1011·46	6·352	621·71	1067·10	5·23
December 31.	47°	1011·47	6·392	625·32	1060·43	4·18
Average . .	48·9	1011·16	6·412	615·62	1046·56	49·88 Total*
1854.						
Hofmann . .	48·2	1011·13	6·348	650·38	1095·51	
1867.						
Muspratt . .			6·732	655·27	1108·78	
1875.						
Thorpe . . .	48·2	1011·04	6·532	613·77	1047·01	
1881.						
Davis . . .		1011·40	6·460	627·57	1048·25	

* This was a remarkably rainy year not only in Harrogate but elsewhere, *e.g.* the rainfall of England was more than one-third in excess of the average of previous years.—*Symonds's British Rainfall*, 1872.

Chloride of Iron Spa.

	Specific gravity.	GRAINS IN IMP. GALLON. $FeCl_2$*	FeO, CO_2.	Chlorine.	Total residue.
1872.					
January	1006·26	34·50	11·84	334·29	523 89
February	1006 47	33·77	11·12	340·19	517·89
March	1006·27	30·10	10·07	335·20	550·80
April	1006·17	28 97	11·33	339 89	557·09
May	1006·32	30·49	11·49	345·54	556·39
June	1006·33	29·88	11·17	346·69	555·43
July	1006·28	30·67	11·82	342 33	549·84
August	1006 12	26·97	9·73	339·68	540 96
September	1006 04	26·36	10·70	335·06	544·16
October...	1006·31	32·27	10·32	334·40	532·04
November	1006·43	31·29	10·92	333·54	534·75
December	1006 25	31·62	10·07	329 53	528·45
Average	1006·27	30·57	10·88	338 02	540·97
1865.					
W. A. Miller	1005·09	14·49	11·62	283·25	465·47
1866.					
Muspratt	—	16·01	10·84	311·68	465.05

* During the year 1872 the Chloride of Iron appeared in remarkably large quantity.

CHAPTER I.

A SKETCH OF THE CHEMICAL CONSTITUTION OF THE HARROGATE WATERS.

The Variety of Waters.

Harrogate is as remarkable for the variety as for the number of its mineral springs; a variety, however, which embraces both the different shades and degrees of any one group of similar waters, as well as several distinct kinds which, as a rule, are only to be met with elsewhere scattered in different localities widely apart. A reputation of over 250 years for Sulphur waters has so associated them with Harrogate in the public and professional mind, that whenever mentioned, the name of the place instinctively calls up the not altogether pleasant conception of "Stinking Wells." It is true these are a rich posession; but it is only to outsiders they appear to completely outvie and overshadow the other medicinal springs. Those engaged, however, in the daily use of the Harrogate waters find the large and important classes of mineral waters outside the sulphur group quite as useful as the latter in the special curative

work allotted to them—work which Sulphur waters alone cannot be made to compass.

The good name of Harrogate should therefore rest not merely on the Sulphur waters which are found there in all varieties—some even unique—but besides, and to at least an equal degree, on many other medicinal springs: and of the latter, it should be noted, some are so remarkable that merely one of them, such as either the Kissengen or the Chloride of Iron water would suffice to establish the reputation of a watering-place.

Classification.

The waters may be broadly divided into such as contain an alkaline sulphide or a proto-salt of iron.

The Sulphur and the Iron groups may each be split into two others; *the first* is characterised by the union of the alkaline sulphide or the proto-salt of iron with a body of saline matter, less or more considerable, and possessing a chemical constitution similar throughout; hence the *Saline sulphur* and the *Saline-chalybeate waters*, which are furthermore divisible into the "strong" and "mild" according to the concentration of the salines; *the second* sub-group is constituted by the sulphide, or the iron-salt being

associated with other salts in comparatively small or in minimal proportions, such as below 20 grains in 20 oz. :—hence arise the *Pure sulphur* and the *Pure chalybeate waters.*

There is, however, one water—the albuminous chalybeate in the Bogs Field—which does not conform to these general statements; it contains a per- as well as a proto-salt of iron, and its other constituents differ from those present in the other waters.

All the numerous and varied medicinal springs of the Harrogate district may be conveniently gathered into the following groups and classes.

GROUP I. Sulphur Waters.

Class 1. *Pure Sulphur Waters.*
(Total solids *not more* than 20 grs. 20 oz.)
Starbeck Sulphur Wells.
Bilton Sulphur Spring.
Harlow Car Sulphur Wells.

Class 2. *Saline Sulphur Waters.*
(Total solids from 30 to 130 grs.)
(*a*) *Strong.* (Total solids *not less* than 120-30 grs.)

The Old Sulphur Spring (Royal Pump Room).

Strong Montpellier Sulphur Well.

(*b*) *Mild.* (Total solids *not less* than 35 grs.)

Mild Sulphur Well (Royal Pump Room).

Mild Montpellier Sulphur Well.

Magnesia Well (the Bog Field and Royal Pump Room).

GROUP II. Iron Waters.

Class 1. *Pure Chalybeates.*

(Total solids *not more* than 5 grs.)

Tewit Spring. (The Stray).

John's Spring. (The Stray).

The Harrogate Pure Chalybeate (Royal Pump Room).

The Carbonate of Iron Well (Cheltenham Rooms).

Class 2. *Saline Chalybeate Waters.*

(Total solids from 27 to 109 grs.)

(*a*) *Strong* (Total solids *not less* than 58 grs.)

Kissingen Well (Montpellier Gardens).

Chloride of Iron Well (Cheltenham Rooms).

(*b*) *Mild.* (Total solids *not less* than 27 grs.)
Alexandra Well (Royal Pump Room).

CLASS 3. *Sulphated Chalybeate.*
(Total solids nearly 50 grs.)
The Alum Well (the Bog Field).

SALINE CONSTITUENTS.

The constituents common to both the saline-sulphur and the saline-iron waters may now be conveniently considered before the members constituting these groups are reviewed. In the several springs the saline matter ranges in concentration from 19 to 131 grains, and possesses a similar constitution in all:—namely chlorine combinations with a small proportion of carbonates. These waters must therefore be classed with the Chloride or Salt springs, with which *only* should they be compared for either purely chemical or therapeutic purposes.

The annexed table sets forth the constitution of the saline basis of the principal Harrogate springs, and of the best representatives of Chloride waters elsewhere; and it will enable the reader to readily recognize the following distinguished features of the former.

The Saline Constituents of the Principal Harrogate Waters, and of the best known Salt Springs—grs. per 20 ozs.

	Chlorine Combinations						Sulphates	Carbonates	Calcium Salts in Total Salines 100.	Calcium Salts	Salts of Ba and Sr
	Chlorides to 100 Total Solids	+ Na	+ K	+ Mg	+ Ca	Total Chlorides					
Old Sulphur Well	94	111	1	6	5	123	0	4½	7	9	½ Ba
Strong S. (Montp.)	97	103	½	8	10	121	‡	1	9½	11	Sr and Ba
Kissengen		84	2½	8	11	105½	‡	2½	12	12	Ba and Sr
Mild S. (Roy. P. Room)	91	72	1½	2½	3½	78½	0	4½	7	6	⅓ Ba
Mild S. (Montp.)	93½	48	½	4	4	56½	‡	2	11	6	⅓ Sr
Chloride of Iron	93	34½	½	7	12	54	0	1½†	20	12	½ Ba
Magnesia	88	27	⅓	⅓	0	30	0	4	6½	2	⅛ Ba
Alexandria	84	20	¼	⅓	2½	23½	1	3	9½	2½	trace Ba
Woodhall—Lincs	99·5	152	0	11	13	176	0	0	8	13	0
Kreuznach (Lowig)	97½	91	¾	5	17	114½	‡	2	16	15	$\frac{1}{100}$ Ba
Hall‖	94½	116	0	2	3½	121½	‡	0	3	3½	0
Wiesbaden (Fresenius)	93½	65	1⅔	2	4½	73	‡	4	11	9	0
Soden‖	90	117	0	0	0	117	‡	12½	12½	11½	0
Nauheim—Kurbrunnen‖	90	137	5	2½	10	154½	‡	14	9	15	0
Homburg (Elizabeth)	87	99	0	9½	9½	118	‡	18	18½	23	0
(Leibig) (Ludwigsbrunnen	90	105½	2½	7½	12	127½	‡	12½	21	24½	0
Kissengen (Ragoczy	75	56½	2½	3	0	61½	9½	10	20½	14	0
(Leibig) (Pandur	76	52		2	0	57	5½		21½	15½	0
Saratoga New-York—Gyser Spring (Walton)	70	70	3	0	0	73	0	32	14	14½	½ Ba and Sr

* Chloride of Iron. † Carbonate of Iron. ‡ Less than ½ gr. § 73 + 11⅔ Am. Cl. ‖ Quoted by Braun.

1. *The Chlorine Combinations.*

Chlorine is combined with the alkaline metals (Sodium and Potassium), the alkaline earthy metals (Barium, Strontium and Calcium), and Magnesium. These chlorides form a larger proportion of the total salines than is found in other muriated waters, except the Woodhall saline.

Chloride of Sodium, as in other salt springs, forms the bulk of the saline residue; but it is associated with the Chlorides of Potassium, Calcium, Magnesium, Barium, and Strontium, in richer proportion than in allied waters.

In *Magnesium Chloride* the Old Sulphur Well, the Montpellier Strong Sulphur and the Kissengen, equal Homburg (Ludwigsbrunnen), and excel by far Kissengen (Ragoczy and Paudur), Wiesbaden and others.

Calcium Chloride is the salt in which lime mainly exists in these waters rather than as Carbonate or Sulphate; and it occurs more largely in the Chloride of Iron, the Kissengen and the Montpellier sulphurs than in the Continental Spas.

2. *Carbonates.*

While most of the springs are alkaline not one is sufficiently so to entitle it to be classed with waters remarkable for alkalinity.

The *Carbonates of the Alkalies* (soda and potash) are present only in the pure sulphur waters outside Harrogate, viz., at Harlow-Car, Beckwith, Bilton and Starbeck.* Their absence from all the saline waters in Harrogate is probably ascribable to a charge of calcium and magnesium chlorides, which are well known to convert alkaline into earthy carbonates (carbonates of lime and magnesia)—chlorides which, however, cannot be detected in the pure alkaline sulphur waters.

In 1870 the late Dr. Muspratt asserted the presence in the Alexandra Water (Bogs Field) of over 2 grains of sodium carbonate as well as 3 grains of the incompatible chlorides of calcium and magnesium in 20 oz.: this chemical incongruity, as well as the fact that no chemist has subsequently succeeded in detecting the presence of a carbonate of an alkali in this water, cast a suspicion on Dr. Muspratt's

* They are, however, reported by Mr. Davis and Mr. Fairley as constituents of the Old Crescent Well, or Leamington Spa in Low Harrogate.

analysis, or rather on the interpretation of results which it represents; hence the writer rejects it.

The absence of alkaline carbonates from the Harrogate salines is not an exceptional fact in the chemical history of mineral waters; for analysts have failed to detect them in all other springs well charged with chlorine salts: for instance in those of

Kissengen.
Homburg.
Kreutznach.
Nauheim.
Wiesbaden.
Pyrmont.
Woodhall.
Cheltenham.
Leamington, etc.

On the other hand waters notable for alkalinity are poor in chlorides: *e.g.*

	Carb. Sod. grs. in 20 ozs.	Chlorides.
Vals (Magdelene)	63·7	·14 Ossian Henry.
Vichy (Celestine)	44·6	·46 Bouquet.
Fachingen	35 0	5·60 Fresenius.
Bilin	28·7	3·60 Reatenbach.
Ems	19·7	9·60 Fresenius.

The *Carbonates of Lime and Magnesia* are found in much smaller proportions in these saline waters than in other muriated springs. (See p. 66).

The Barium and Strontium combinations with chlorine and carbonic acid are so important from a therapeutic standpoint as to demand separate notice.

3. *Barium and Strontium Salts.*

Barium chloride was discovered in 1865 by the late Prof. Miller in the Chloride of Iron water:—not, however, as is usual when recorded in mineral waters, as a mere trace, but in the large proportion of $\frac{4}{5}$ of a grain in 20 ozs.; and in 1866 Mr. R. Hayton Davis, F.C.S., estimated Barium salts in the

Kissengen.
Old Sulphur Spring.
Strong Montpellier Sulphur.
Mild Montpellier Sulphur.
Magnesia Water.

And, moreover, this observer, was the first to gravimetrically determine the salts of Strontium in these waters.*

The Barium and Strontium impregnations of these

* *The Chemical News*, 1866.

springs have since been confirmed by Muspratt in 1867 (Old Sulphur Spring, Kissengen, and Magnesia Water), Thorpe in 1875 (Old Sulphur Spring) and in 1881 (Chloride of Iron water) and Attfield in 1879 (the Montpellier Sulphur and Kissengen Wells), and furthermore, these salts have been determined in the Royal Pump-room Mild Sulphur by Muspratt and Miller. The presence of large proportions of Barium and Strontium salts in these by far the most important of the Harrogate waters during the past 15 years has therefore been attested by several competent analysts, and precludes the possibility of doubt.

The latest and most trustworthy analyst of the Old Sulphur Spring—Prof. Thorpe—thus refers to the Barium salt which he estimated in 1875. "The amount of barium salt in the water is unusually large, and appears to be increasing. So far as is known, no mineral springs in this country or on the Continent contain so large a proportion of this substance as the Harrogate waters. The quantity indeed in the Old Sulphur Well is as large as the entire amount of soluble matter contained in many of the waters used for domestic supply in our towns. So potent an agent present in such large proportion must undoubtedly exercise considerable influence on

the therapeutic action of the water; and therefore it is highly desirable that the determination of its amount should be repeated from time to time."*

The latest Estimations of Barium and Strontium Salts in the Harrogate Waters: gr. in 20 oz.

	Barium Salts.	Strontium Salts.	Analyst.
The Old Sulphur Spring	·820	—	Thorpe 1875.
	·770	—	Davis 1879.
	·845	—	Davis 1881.
Chloride of Iron	·811	—	Miller 1865.
	·794	—	Davis 1879.
	·676	—	Thorpe 1881.
Kissengen	·331	·111	Attfield 1879.
Magnesia...	·153	—	Muspratt 1867.
Mild Sulphur (Royal Pump Room)	·095	—	Miller 1869
Strong Montpellier S.	—	·418	Attfield 1879.
Mild Montpellier S.	·052	·191	Attfield 1879.

It would appear from these analytical results that Barium is more abundant than Strontium in the Harrogate waters; while in other medicinal springs in which these constituents appear the former is the more uncommon. The Old Sulphur Spring, (the strongest Sulphur water) and the Chloride of Iron (the strongest Iron water) contain larger proportions of Barium than have been estimated elsewhere—exceeding the largest recorded charge by 4 to 1; and the Montpellier Strong Sulphur is the richest strontium water by nearly 2 to 1.

* *Philosoph. Mag. July*, 1876.

Barium and Strontium in Mineral Waters: grs. in 20 oz.

	Barium Salts.	Strontium Salts.	Analyst.
Harrogate Waters from	·052	·111	
to	·845	·418	
Saratoga (Congress Springs) Geyser } the Hathorn } strongest	·206 ·178	·041 trace	Walton.
Luhatschowitz Vincenbrunnen ...	·087	·116	Fersth.
,, Luisenquelle ...	·075	·150	
Kreuznach, Elizenquelle	·012		Lowig.
Weilbach...	·010	·001	Fresenius.
Hunyadi Janos	—	·235	Buusen.
Franzensbad, Weisenquelle... ...	—	·061	Berzelius.
Carlsbad, Malktbrunnen	—	·047	Wolf.
Leuk...	—	·039	Brunner.
Toplitz	—	·034	Wolf.
Marienbad, Kreuzbrunnen	—	·021	Kersten.

Others (*e.g.*, Fachingen, Aix-la-Chapelle, Ems, Baden Baden, Seidlitz, Vichy, Birresborne) contain still smaller proportions of Barium and Strontium salts.

The chemical reason why the soluble salts of Barium and Strontium are permitted to appear so largely in some of the Harrogate waters is not far to seek; it is furnished by the absence of soluble sulphates which characterizes these springs. From the well known paramount affinity of Barium and Strontium for sulphuric acid and the insolubility of the sulphates thus formed,* it follows, in order to obtain in

* Sulphate of Barium is, however, *sparingly* soluble, and the Strontium Sulphate is somewhat more soluble in saline solutions: hence small quantities of these salts have been detected in some of these waters.

natural solution a pronounced proportion of Barium or Strontium, soluble sulphates must be absent, or laid by precipitation by some excess of the soluble salts of Barium or Strontium long before the water issues from the earth; but inasmuch as soluble sulphates are found generally in medicinal springs the rarity of waters highly charged with Barium and Strontium is apparent.

4. *Salts of Lime.*

These are recorded by analysts as Calcium Chloride and carbonate:—the former in much larger proportion than the latter; while in other muriated waters the reverse obtains.

When objections are raised as to the presence of Lime in medicinal springs, they should apply more particularly to the Sulphate and Carbonate than to the Chloride; of the former, the Sulphate is a comparatively rare constituent of the Harrogate waters, and, when detected, it is found in little more than traces (see sulphates): and the Carbonate appears in much smaller quantities than in most other salt springs. And, moreover, the total charges of lime salts in the waters containing effective doses of aperient salts (the Old Sulphur Spring, the Mont-

pellier Strong Sulphur and the Kissengen waters) are smaller than those recorded by analysts in the salt springs of Kreuznach, Nauheim, Kissengen, Homburg and Saratoga. The checking influence which they are apt to exert on the aperient quality of a water is, however, more correctly expressed by the *percentage* of them in the total salines; and this view of the matter brings out still more clearly the same conclusion, *e.g.*, the average charge of Lime in the aperient Harrogate waters is only 9 per cent. while it is at least 21 in the Kissengen springs (Ragoczy and Pandur).

The assertion as to the Harrogate aperient waters containing more lime than those of Kissengen* or other continental springs is therefore without foundation. Furthermore, af all chloride waters, the Magnesia water contains the least amount of Lime, and in this particular the Mild Sulphur (Royal Pump Room) and the Montpellier Mild Sulphur waters are only excelled by Hall—a water remarkably free from earthy salts.

On the other hand the Chloride of Iron well is richly charged with Calcium Chloride, and the Montpellier waters contain more of this salt than the other Harrogate waters.

* See p. 217 *The Curative Effects of Baths and Wells*, by Dr. Braun, Lond. 1875.

5. *Sulphates.*

The Harrogate waters like other chloride springs* are either Sulphate-free (as the Old Sulphate Spring, the Mild Sulphur—Royal Pump Room—the Chloride of Iron, and the Magnesia water) or contain but mere traces of Sulphates. The absence of indigestible and constipating Sulphates—particularly Calcium Sulphate—is a fortunate chemical fact in the constitution of these salines. "A glance at the amount of sulphate of lime contained in the usual mineral waters will show that it is just those which contain little or no sulphate of lime that are drunk most frequently and in larger quantities, and that in proportion with the increasing amount of gypsum in the others in the doubtful character of their reputation."† Nearly all the saline springs of this country well charged with chlorine salts—save Woodhall Spa—contain a large proportion of Sulphates, *e.g.*, these salts constitute about one-half the total contents of the Cheltenham and Leamington waters, which are therefore chemically allied to the Bitter waters rather than to the Muriated, or they may be classed as occupying an intermediate position between purely Sulphated and Chlorided springs.

* Kissengen springs and Pyrmont are, however, notable exceptions.

† *Curative Effects of Baths and Waters*, by Dr. Braun, p. 426.

CHAPTER II.

THE SULPHUR WATERS.

The Constituents Compared with those of other Sulphur Waters.

The constitution of all the Harrogate Sulphur waters, and the relation it bears to that of other similar springs will be illustrated best by reviewing, in the first place, the chemical agents from which they derive their sulphuretted properties, and then, the constituents associated therewith.

1. *Sulphides.*

The form in which Sulphur is presented in these waters is a matter of much chemical and therapeutical interest. In the majority of sulphur waters it is recorded by analysts combined with hydrogen as sulphuretted hydrogen gas (H_2S) but in every member of the Harrogate sulphur group this combination, though undoubtedly present, represents

but a portion, and, that generally, a small portion of the total sulphur charge, and is subsidiary to—possibly derived from—an alkaline sulphide. In 1843 Dr. Bennett* states there is no free sulphuretted hydrogen present in these springs, but that sulphur exists in combination with calcium and sodium. This position has, however, been somewhat shaken by later analysts (*e.g.*, Prof. Hofmann in 1853 and Prof. Muspratt in 1867) who record the sulphur combinations as free sulphide gas in small proportion, and an alkaline (sodium) sulphide representing the bulk of total sulphur.

Prof. Thorpe, who in 1875 analysed the most important of these springs—the Old Sulphur—says† "It would seem to be certain from the above determinations that it (sulphur) exists entirely as a sulphide, either as hydrogen or alkaline sulphide, or more probably in both forms" and further "it is quite certain that a portion of the sulphur in the water exists as free sulphuretted hydrogen;" and this analyst distributes the sulphur nearly equally between an alkaline sulphide salt (sulph-hydrate of

* *Treatise on the Sulphurous Springs of Harrogate*, 1843.

† *A Contribution to the History of the Old Sulphur Well, Harrogate* by T. E. Thorpe, Ph.D., F.R.S., Professor of Chemistry in the Yorkshire College of Science, Leeds, *Philosoph. Magaz., July*, 1876.

sodium—NaHS) and the free gas (H_2S). From this consensus of analytical results the presence in these waters of an alkaline sulphide embodying a considerable portion of the sulphur, besides that of free sulphuretted hydrogen may be safely inferred.

The therapeutic advantages of sulphur waters—such as those of Harrogate—charged mainly with sulphide Salt rather than Gas are obvious; for while the latter is apt to be quickly dissipated by exposing the water,* and to be dispelled by eructation, the former meeting the acids of the system, evolves sulphuretted hydrogen throughout the body—the water containing it becoming actually stronger in gaseous sulphide after imbitition and absorption.

* Hence Fardel thus speaks of the waters of Aix-les-Bains: "Fontan remarks that the waters of Aix are slightly sulphuretted. It would be, perhaps, more correct to say that they very quickly lose their sulphur principle. They also deposit much sulphur and a quantity of sulphuric acid, which proceeds to organise itself in forming sulphates upon the walls, the iron-works, the timber it encounters, reddening the material." *Traité Therapeutique des eaux minérales de France et de l'etranger, par Durand-Fardel*, 1857.

Indeed those waters containing merely sulphuretted hydrogen, freely emitting the characteristic odour of this gas, may be readily regarded by the casual observer as stronger sulphur waters than those sulphided purely by a sulphide-salt containing much more sulphur available as a remedy: apart from any difference in the original impregnation with the respective sulphides, this erroneous impression arises from the gaseous form rapidly leaving the water while the saline sulphide remains in solution.

The silica and carbonic acid with which the Harrogate are better endowed than other sulphur waters, will determine the conversion of a small portion of sodium sulphide (Na_2S) or sulph-hydrate (NaHS) into sulphuretted hydrogen, and may thereby account for the modicum of free sulphide gas recorded by Hofmann and subsequent analysts; according to the formulæ:

$$Na_2S+H_2O+CO_2 \text{ or } SiO_2=NaCO_3 \text{ or } NaSiO_3+H_2S$$
$$2\,(NaHS)+2\,(H_2O)+2\,(Co_2 \text{ or } SiO_2)=2\,(NaCO_3 \text{ or } NaSiO_3)+2H_2S$$

The principal sulphur waters reported by analysts to be sulphided mainly or entirely by an alkaline sulphide are recorded in the following table, in which it may be noted the charge of this salt in the strongest Harrogate sulphur waters is only excelled by that of Challes; and, as a class, with this sole exception they contain more sodium sulphide than has been discovered in other sulphur waters.

		Parts of Alkaline Sulphide in 10,000 Parts of Water
The strongest Harrogate Sulphur Waters.	Strong Sulphur (Montpellier)	2·07
	Old Sulphur Well	1·18
	Mild Sulphur (Montpellier)	1·25
	Mild Sulphur (Roy. Pump R.)	·98
Challes (latest analysis, Willin)		3·59
Mehadia (latest analysis, Schneider and Kottsdorfer)		1·07
Luchon		·77
Marlioz		·67
Le Vernet		·59
Massena		·56
La Bassère		·46
Cauterets		·30
Strathpeffer		·26
Barèges		·22
Eaux Bonnes and St. Sauveur		·21
Amélie		·12

According to published analyses, nearly all other sulphur waters are sulphided entirely, or almost so, by free sulphuretted hydrogen gas.

In determining the charge of sulphur for purposes of comparison some standard must be adopted:—either the total sulphur contained in the sulphide combination calculated and represented as such, or in cubic inches of sulphuretted hydrogen; the writer prefers the total sulphur standard. It is, however, difficult if not impossible to gauge accurately gradations of the actual sulphide strength of different springs, for in nearly all it depends largely on the hydrogen sulphide—a gas which is subject to great variations in quantity, determined by temperature,

atmospheric pressure and other causes; comparisons within limited ranges cannot, therefore, be reliably made, and fine distinctions should not be attempted. And furthermore, "as Harrogate is almost the only place that has of late years had its sulphur waters completely analysed, it is very difficult to compare the quantity of its sulphuretted hydrogen with that of other places, the waters of which have been examined less carefully."†

The reader will derive a clear notion of the positions occupied by the several Harrogate Sulphur Waters, as to the proportions of sulphur—contained in the sulphides—and of total contents, among other best known sulphur springs, by perusing the following tables, framed after those of Dr. Macpherson—in which the calculations of the amount of sulphur present were taken from Lersch's Hydro-chemie.‡ The author's additions are marked by an asterisk, and the Harrogate Waters are in brackets.

Cold Sulphur Waters.

	Parts in 10,000. Sulphur.	Total Content
*Challes (Willin, see Compt. Rend., v. 86)	2·100	12·1
*Challes (Corrigon)	1·970	10·2
[Old Sulphur Well	·923	148·0]
[Strong Montpellier S.	·824	143·2]

† *Our Baths and Wells*, by J. Macpherson, M.D., 1871, p. 121.

‡ *Baths and Wells of Europe*, 1873, p. 150.

	Parts in 10,000. Sulphur.	Total Contents.
*Strathpeffer (Thomson)	·206 to ·668	16 to 59
*Eilsen	·578	27·1
[Mild Sulphur (Royal Pump Room)	·615	97·2]
[Mild Montpellier S.	·514	69·3]
Enghien	·435	30·7
*Askern (Lankester)	·420	25·5
Nenndorf	·326	27·6
*Marlioz (Bonjeau)	·275	4·2
*Massena, America (Mayer)	·259	19·8
La Bassère	·203	4·8
Langenbrucken	·064 to ·28	13·0
*Lisdoovarna, Ireland (Apjohn)	·214	3·7
[Harlow Car	·168	5·9]
[Beckwith (R. H. Davis)	·157	4·7]
Uriage	·150	141·0
*Croft New Well (Canney)	·130	3·7
*Guagno (Poggiale)	·098	2·6
[Magnesia Well	·094	40·0]
[Bilton (R. H. Davis)	·080	14·4]
[Starbeck	·080	21·6]
Weilbach	·071	11·6
*Moffat (Johnstone, see *Chem. News*, vol. 31)	·026	15·0
Gurnigel	·015	19·3
Cambo	·012	32·4

All the *warm* sulphur waters are feebly sulphided except Schinznach; this is, however, rivalled by the Old Sulphur Spring, which is "perhaps the strongest sulphur well in Europe, at least, of those whose constitution is well ascertained. It is as strong as the strongest well at Schinznach."† Hence it is sufficient to contrast the sulphide charge of merely the *milder* sulphur waters in and around Harrogate with that of *warm* sulphur springs.

† *Our Baths and Wells, op. cit.*

Thermal Sulphur Waters.

1. *Containing less Sulphur than the Magnesia Water.*

	Parts in 10,000. Sulphur.	Total Contents.
La Preste	·054	1·3
Eaux Chaudes	·048	3·0
Aix-la-Chapelle	·039	41·0
*Aix-les-Bains (Willin)†	·071	4·8
Burtscheid	·007	38·0
*Molitz (Bouis) and Bagnols (Henry)	below ·006	1·5 to 6·1

2. *Sulphur less than in Harlow Car Springs.*

*Amélie (Anglanda)	·165	3·0
Olette	·124	4·3
*Saint Gervais (Bourne and Grange)	·102	50·4
Saint Sauveur	·097	2·5
Eaux Bonnes	·096	6·0

3. *Less Sulphur than in Mild Sulphur (Royal Pump Room).*

*Mehadia (Schneider and Kottsdorfer)‡	·57 to ·63	61·1 to 71·9
Acqui	·299	63·0
Luchon	·230	2·5
*Labassère (Filhol)	·188	4·8
Vernet	·177	2·7
Barèges	·176	2·1
Stachelberg	·141	5·3
Abano	·078 to ·154	65·9
Cauterets	·135	1·8

The sulphide strength of the Old Sulphur Well has been frequently misstated by writers on mineral waters: the modicum of sulphur represented by the free sulphuretted hydrogen having been recorded

† See *Compt. Rend.*, vol. 86.

‡ See *Wiln. Akad. Ber.*, 64.

without reference to the larger portion allied to sodium, and thus held in solution by the water; doubtless an accidental omission, but, nevertheless, apt to impair the reputation of the spring, and to permit the pretensions of less valuable sulphur waters to flourish on what appears to be the whole truth.

Inasmuch as it has been asserted, for example, that the Strathpeffer water surpasses the strongest Harrogate spring in the sulphur element—leaving it open for any one to infer it is more strongly sulphided—a passing notice must be given to the grounds on which this allegation is based. They are set forth in the following passages. "Being sulphurous they belong to the same class as the sulphur waters of Harrogate, Moffat and Aix-la-Chapelle. The sulphur element however, in one or other state, enters more largely into them than into any of these. It exists in combination with hydrogen, forming sulphuretted hydrogen gas, and as an element in several sulphate salts, forming the sulphates of magnesia, lime, and soda, and as a sulphuret in combination with potassium, sodium, and iron, and by itself in a state of suspension. There exist altogether in the water of the Strong or New Well, the sulphates being taken into account, a little over thirty grains of sulphur to the

imperial gallon. In the strongest sulphur water of Harrogate, the quantity of sulphur is some eight grains to a gallon; while in the Moffat water it is little more than two thirds of a grain; the sulphur in the two last being in combination with hydrogen and sodium only, forming sulphuretted hydrogen gas and sulphuret of sodium. . . . . With regard to the quantities of sulphuretted hydrogen gas, it will be seen by reference to the analysis, that while the strongest Harrogate water contains 5·31 cubic inches to the gallon, and the Moffat a little over a third of a cubic inch, the Strathpeffer New Well contains 11·26 cubic inches, which is the largest quantity of sulphuretted hydrogen in any known spring in Great Britain. Aix-la Chapelle has the gas represented by only 0·73 grains of sulphuret of sodium to the gallon." *

It is scarcely necessary to remark, that in estimating the sulphur strength of sulphuretted springs the invariable rule is to take the *sulphides only* into account; the position of the Strathpeffer water must therefore be determined apart from sulphates † and

* *On the Sulphur Waters of Strathpeffer.* By D. Manson, M.A., M.D., 1879.

† It may be said that sulphides may be generated within the body after imbibition of waters containing sulphates, and it may be argued, therefore, these salts should be included—being possible

free suspended sulphur.* Its sulphide charge is, however, large, and places the water high in the scale of similar springs; but it only slightly exceeds that of the mild saline sulphur waters of Harrogate, and is about one-third less than that of

sources of sulphides—with the ordinarily recognized sulphide charge of sulphur waters. The same line of reasoning may lead to the classing of Hunyadi Janos, Friederichshall and other strongly sulphated waters, with sulphur waters. But it is extremely doubtful if sulphates taken into the system are generators of sulphides as therapeutically available as those actually present in sulphur waters. The deoxidation of sulphates is not effected in the *blood;* hence the remark of Braun: "The formation of this gas (SH_2) by sulphates in the *blood* has never been observed, and it is also highly improbable," and if it be asserted the presence of decomposing organic matter in the *alimentary canal* may enable sulphuretted hydrogen to be liberated from sulphates, this fact may be accepted as true; but the gas thus generated cannot be therapeutically of any value, inasmuch as it is only found in the large intestine, where feculent matters are apt to lodge or move on very slowly, and absorption is very limited compared with that of the stomach and small intestines and expulsion a greater probability: or as Braun says, "but in the *intestinal canal*, where sulphates very frequently develop sulphuretted hydrogen, this gas is rarely absorbed, but it passes away with other gases of the intestines." Hence authorities are justly agreed in accepting sulphides as the only reliable source whence sulphur waters derive their chemical and therapeutical properties.

* The sprinkling of *free* sulphur in the Strathpeffer waters is not likely to share the physiological and therapeutic effects of sulphides: for crude sulphur and sulphides appear to possess the properties of two distinct remedies.

the Old Sulphur Well. According to published analyses the sulphides of the Strathpeffer and the Old Sulphur stand thus :—

	Strathpeffer.	Old Sulphur Well.
Alkaline Sulphide, gr. .	·228	·908
Hydrogen Sulphide, cu. in. .	1·407	1·270

That is, the sulphide gas is nearly equal in both, and the sulphide salt in the Old Sulphur Well is nearly fourfold that in the Strathpeffer Strong Sulphur.

2. *Saline constituents.*

A prominent chemical feature of the Harrogate sulphur waters is at once recognized by any one glancing over the analyses, namely, the presence in the majority of them of a considerable body of saline matter. This fact has coloured the reputation of the whole group, and inclined medical writers to treat all the Harrogate sulphur waters as salt springs.* All degrees of saline concentration are, however, represented, from that of the strongest sulphur saline known to chemists, to the small charge of some of the purest sulphur springs.

The general survey of the leading chemical features of the saline constitution of the Harrogate waters already given, must now be compared with

* See the *Baths and Wells of Europe* (Dr. Macpherson): *The Curative Effects of Baths and Wells* (Dr. Braun).

that of other sulphuretted springs. The principal distinguishing points relate to—(*a.*) Chlorine combinations; (*b.*) Sulphates; (*c.*) Barium and Strontium; (*d.*) Alkaline salts; (*e.*) Iodine and Bromine.

(*a.*) Chlorides.

The following table shows the Harrogate sulphur group to be more richly endowed—both relatively to other saline constituents and absolutely—with Chlorine salts than any other sulphur waters: the strongest members containing beyond twice the largest charge elsewhere—Uriage; and, moreover, the Harrogate series presents several gradations of chloride impregnation. The practical value of this combination of Chlorides with Sulphides rests on the similarity of the curative properties of both—their union enforcing the power of each.

Chlorine Combinations in Sulphur Waters.

	Chlorides. grs. in 20 ozs.	Proportion of Chlorides to 100 Parts Total Solids.	
[Old Sulphur Spring	123	94]	
[Strong Montpellier S.	121		
[Mild Sulphur (Royal Pump Room)	78½	91]	
[Mild Montpellier S.	56¼	93⅓	
[Magnesia	30	88]	Analysts.
Uriage	56½	58	Lefort.
Aix-la-Chapelle.	25	64	Liebig.
Saint Gervais (S. de Torrent)	17	38	Bourne.
Moffatt	10	88	Macadam.
Schinznach	6	31	Grandeau.
Burtschied	27	70	quoted by
Mahadia	23	94	Braun.

The published analyses of other sulphur waters, as a rule, indicate the presence of less than 5 grains of Chlorides to the pint. The medical resources of Harrogate, however, afford the choice of sulphur waters, not merely more chlorided than others, but also such as contain Chlorides in the smallest proportions, such as those of Starbeck, Bilton, Harlow Car, and Beckwith.

(*b.*) Sulphates.

Sulphur waters are, as a rule, rich in Sulphates. Out of 29 of the best known Spas, according to the analysis of 22 these salts form more than one-fourth—and of several of these, even one-half and three-fourths—of the total contents; and six possess a minor yet moderate quantity of Sulphate—while there remains but one recorded as Sulphate-free—Harkang. The Harrogate sulphur springs in this respect contrast remarkably; three—the Old Sulphur spring, the Mild Sulphur (Royal Pump Room) and the Magnesia waters—are Sulphate-free, and the others contain merely Sulphate traces.

Sulphur waters are apt to contain the indigestible and constipating Sulphate of Lime in considerable quantity: *e.g.*

	grs. in 20 ozs.	
Uriage	13⅓	(Lefort.)
Baden (Swetz)	13½	(From data furnished by Braun.)
Eilsen	12	
Kreuth	10½	
Nenndorf	10	
Burtschied	7¼	
Strathpeffer	6⅓	(Thomson.)

The absence of this salt from all the sulphur salines of Harrogate should be noted as a remarkable exception to the ordinary chemical constitution of other sulphur springs.

(*c.*) Barium and Strontium.

These rare constituents of medicinal springs, present in large proportion in several members of this group, are recorded in only a few sulphur waters elsewhere, and then in quantities scarcely exceeding traces. The Old Sulphur Well is the strongest known Barium water, and the Strong Montpellier Sulphur excels all other waters in Strontium.

(*d.*) Alkaline Salts.

Sulphur springs rarely contain more than mere traces, or feeble quantities, of Alkaline salts. The *highest* recorded charges are the following :—

Cold S. Springs.

	Sod. Carb. grs. in 20 ozs.	Analyst.
Uriage	4·8	Lefort.
Weilbach	3·8	Fresenius.
Challes.	1·5	Henry.
Guagno	1·1	Poggiale.

Warm S. Springs.

Aix-la-Chapelle . . .	6·0	Liebig.
Burtschied	6·0	Quoted by Braun.
Molitz	2·9	Bouis.
Bagnols	2·0	Henry.

These salts, as previously stated, do not appear in the strong Saline sulphur waters, but are found in the Pure sulphur springs to the east and to the west of Harrogate.

	Sod. Carb.
Beckwith	2·0
Harlow Car	1·9
Starbeck	1·8
Bilton	Abundant.

These issues excel in Alkaline Carbonates other cold sulphur springs—except those of Uriage and Weilbach; and these are weaker sulphur waters (see p. 83).

(*e.*) Iodine and Bromine

Have been discovered by Professor Thorpe in the Old Sulphur Well, and he records them as allied with magnesium. These elements, are rarely met

with in sulphur waters. The water of Challes is believed to contain them in larger proportions than other sulphur springs. The quantities estimated by Professor Thorpe in the Harrogate Sulphur exceeds, however, those of Challes by more than 2 to 1: and those of Marlioz—another celebrated Bromo-Iodized sulphur spring—by 12 to 1.

	Parts in 10,000 of Water.		
	Iodine and Bromine.	Iodine.	Bromine.
Old Sulphur Well (Thorpe) . . .	·2951	·0146	·2805
Challes (Willin)*	·1337	·1045	·0292
,, (Corrigon)	·1050	·0890	·0160
Aix-les-Bains (Ossian Henry) . .	·0006	·0004	·0002
Marlioz (Bonjean)	·0024	·0019	·0005

The Iodo-Bromide charge of the Old Sulphur Well vies even with that of Kreuznach.

Kreuznach (Potstorf)	·0820	·0035	·0785
,, (Lowig)	·3900	·0457	·3445

3. *Gases.*

Sulphur waters are, as a rule, singularly poor in gases, and in carbonic acid gas in particular; many of them do not contain the latter, *e.g.* the Pyren-

* Recent analyses, see *Compt. Rend.*, vol. 86.

ean Spas; compared with others the Harrogate sulphur waters are remarkably well charged with this and other gases; in this respect, they are only excelled by a few, such as Langenbrücken and Nenndorf.

The Montpellier Sulphurs (strong and mild) are better aërated than the rest.

The Saline Sulphur Waters.

All the sulphur waters in Low Harrogate and the Bogs Field are of this class; their sulphides and salines present all degrees of concentration.

The strong waters (the Old Sulphur Spring and the Strong Montpellier Sulphur) are the only sulphur waters known, at home or abroad, so richly charged with *both* sulphides and salts.

In the table, page 82, the reader will note the *sulphide* impregnation of these springs is only excelled by that of Challes, which is specially weak in salts; and the *saline* charge is only approached by that of Uriage, which, however, contains less than one-sixth of the sulphur charge of the Old Sulphur Well: and, moreover, one-seventh of the salinity of Uriage is due to sulphate of lime—a salt which is not present in the Harrogate Sulphur Spring, and which

is believed by all authorities to be an undesirable constituent of an evacuant mineral water.

The Pure Sulphur Waters.

The issues at Bilton, Starbeck, Harlow Car and Beckwith must be classed with other Pure sulphur springs: for, as in these, their sulphides are associated with only a small proportion of other constituents. They are all moderately well sulphided (see table p. 83), and, besides, contain alkaline carbonates in such quantity as to place them high among other Alkaline sulphur waters (see p. 92).

Analyses of the Sulphur Waters.

	Grains in 20 ozs.										Cubic Inches in 20 ozs.
	Chloride of				Carbonate of						
	Sodium.	Potassium.	Magnesium.	Calcium.	Calcium.	Magnesium.	Sodium Sulphide.	Silica.		Total Solids.	Gases.
Old Sulphur Spring. Analyst, Thorpe, 1875.	111·708 Traces of	1·199 Calcium Aluminum	6·035 Fluorina and	5·451 ide and Organic	3·721 Phosphate;	·748 Strontium	·652* Chloride,	—	Barium Chloride ·820 Lithium Chloride ·094 Ammonium Chloride ·129 Magnesium Bromide ·285 Magnesium Iodide ·013	130·945	CO_2 = 5·012 H_2S = 1·270
Strong Sulphur (Montp.). Analyst, Attfield, 1879.	103·421 Traces of	·602 Iodides,	7·249 Bromides,	9·992 Fluorides,	1·094 Lithium.	—	1·813	·446	Barium Sulphate ·052 Strontium Chloride ·352 Strontium Sulphate ·066 Sodium Nitrate ·112 Ammonium Chloride ·124 Iron Carbonate ·052	125·375	CO_2 = ·500 CH_4 = ·287 N = ·462 O = traces.
Mild Sulphur (Royal Pump Room). Analyst, Miller, 1869.	72·868 Traces of	1·417 Lithium	2·475 m Chloride.	3·863	2·300	2·100	·861	·300	Barium Chloride ·098	86·282	CO_2 = 3·480 H_2S = 1·436 N = ·847
Mild Sulphur (Montp.). Analyst, Attfield, 1879.	48·60 Traces of	·711 Barium Salts.	3·449 m Sulphate, Iod of Lithium and Iron.	3·912	2·089	— ides, Bromides,	1·097 Fluorides,	·479 and	Strontium Chloride ·077 Strontium Sulphate ·114 Sodium Nitrate ·046 Ammonium Chloride ·082	60·656	CO_2 = 6·750 CH_4 = ·100 N = ·400
The Magnesia Water. Analyst, Muspratt, 1867.	26·987 Traces of	3·489 Strontium Chloride, Iron Carbonate and Bromide.	·224 Lithium, Sodium Iodide.	—	2·309	1·600	·201	·201	Barium Chloride ·153	85·051	CO_2 = 1·450 CH_4 = ·683 N = ·751 O = ·240
Starbeck Sulphur. Analyst, Fairley, 1879.	14·555 Traces of	— Lithium and Barium Chloride.	—	—	1·251	·439	·170	·408	Sodium Carbonate 1·809 Potassium Carbonate ·081 Calcium Sulphate ·235	18·948	Not estimated.

* Sodium Sulph-hydrate (NaHS) equivalent to ·908 Sodium Sulphide.

CHAPTER III.

THE IRON WATERS.

THE Iron-Salts present in the Chalybeate Springs are:—

1. The Proto-Carbonate.
2. The Proto-Chloride.
3. The Proto- and Per-Sulphate.

I. THE SALINE CHALYBEATES.

The Chloride of Iron and the Kissengen Wells are the best representatives of this group. They are both rich in iron and salts; the former, however, more forcibly illustrates the Chalybeate, and the latter the Saline side of the constitution of Ferrated-Saline waters. The Alexandra water furnishes a connecting link between them and the pure Chalybeates.

The Chloride of Iron Water.

The following prominent features place this water in a unique and distinguished position among other medicinal springs.

1. *Iron Salts.* The Chalybeate charge is one of the strongest among potable iron waters: whether pure or compound, at home or abroad. It is derived

from both Ferrous Chloride and Carbonate—the former predominating. Protochloride of Iron is undoubtedly a very rare constituent of chalybeate waters. The writer believes it has hitherto been detected in two other springs only; namely, at Alexisbad — the Selkebrunnen bath Spring — and Buckowina; but, according to the published analyses of these waters, it is present in much smaller quantity in both than in the Harrogate Chloride; and is, moreover, associated with Ferrous Sulphate, and in Buckowina also with Alum; and, furthermore, in these springs the iron salts are not accompanied by Chlorine combinations, as in the Chloride of Iron water; in constitution, the latter, therefore, differs widely from the Chalybeates in which Proto-Chloride of Iron has hitherto been detected.

2. *The Saline Constituents.* The presence of a considerable quantity of saline matter with a large proportion of iron salts, somewhat allies this water to Compound iron springs. But it differs from other members of this class of mineral waters, in possessing a charge of salts *purely chloride;* it is, in fact, *the only ferruginous water known in which iron is linked purely with Chlorides:* earthy sulphates, carbonates, &c. (the ordinary constituents of strong iron waters) being absent.

In Saline constitution this spring is, therefore, unique.

3. *Barium* is recorded by analysts (Miller, Muspratt, Thorpe) in the most soluble form—that of Chloride. This is not merely the only known Chalybeate containing Barium, but it stands unrivalled among all mineral waters, in holding the largest known charge of this powerful medicinal agent—the Old Sulphur Spring alone excepted.

4. *Manganese and Bromine.* Professor Thorpe—the latest analyst of the water—has detected *Chloride of Manganese.* Hitherto a trace of manganese has been recorded; now it appears as chloride, in the proportion of $\frac{1}{5}$ gr. (calculated with its 4 atoms of water of crystallization) in 20 oz.; this is a rare constituent of medicinal springs in quantities beyond mere traces. The writer is only acquainted with two estimations of manganese in other waters—both ferruginous—which exceed Professor Thorpe's: the published analyses of all other springs indicating much smaller quantities.

Manganese:

	Part per 10,000 of Water.	
Pyrmont (Neubrunn)	·55	Wiggins.
Marienbad (Ferdinandbrunn) . .	·08	Kersten.
Schwalbach (Stahlbrunn) . . .	·06	Fresenius.
The Chloride of Iron Water . .	·06	Thorpe.

For the first time in the analytical history of the

water, *Bromine* (recorded as Magnesium Bromide) has been quantitatively determined.

The Kissengen Water.

The Harrogate Kissengen is the sole representative in this country of the strong chloride waters efficiently charged with iron—a class of medicinal springs possessing even but few foreign members.

Though deriving its name from the Kissengen Springs, the solid contents of the Harrogate Kissengen are more closely allied chemically to those of Homburg, as may be gathered from the following table:—

	Total Solid Contents, 100.			
	Chlorides.	Sulphates.	Earthy Carbonates.	Iron Carbonate.
Harrogate. Kissengen.	97	·06	1·2	1·09
*Homburg. Stahlbrunnen.	91	·30	7·1	·89
Elizabethbrunnen.	87	·35	12·0	·42
*Kissengen. Ragoczy.	75	11·4	12·4	·36

The resemblance to Homburg is shown by the almost total absence of sulphates (while $\frac{1}{9}$ of the

* Calculated from Liebig's analyses.

total contents of the Ragoczy Spring are sulphates), by the large proportion of chlorides to other salts, by the high charge of carbonate of iron (far exceeding that of Kissengen), and by a similar though somewhat smaller concentration of solid constituents. The reader will, moreover, gather from the table on p. 66 that the Magnesium and Calcium Chlorides of Homburg are in much the same force in the Harrogate Kissengen.

The Alexandra Water.

This spring somewhat resembles the stronger waters; it is, however, less ferruginous than the Chloride of Iron, and less saline than the Kissengen. It possesses a saline concentration suitable for tonic medication, with a preponderance of Sodium Chloride to accompany the charge of Iron in the process of absorption, and a minimal quantity of Potassium Chloride.

II. Sulphated Chalybeate.

The Aluminous Chalybeate, or the Alum well, differs totally from all the other waters of Harrogate: inasmuch as sulphates form the bulk (90 per cent.) of its total constituents, and of these ferrous and ferric sulphates furnish 60 per cent. The well has

been carefully analyzed by Mr. R. Hayton Davis, F.C.S.

			Grains per 20 ozs.
Fe	5·94	Ferric Sulphate	9·84
		Ferrous ,, ...	8·67
Al	1·78	Aluminium ,, ...	11·19
Ca	2·19	Calcium ,, ...	7·11
Mg	1·43	Magnesium ,, ...	7·17
K	·17	Potassium ,, ...	·39
NH_4	·07	Ammonium ,, ...	·27
Na	1·67	Sodium Chloride	4·25
SiO_2	·41	Silica	·41
Cl	2·57	Radicals.	
So_4	33·18		
	49·41		49·30

The following extract from Mr. Davis's paper on this well, read before the Chemical Society of London, and which appeared in the Journal of the Society, contains the best account of it hitherto published.

"Dr. Thomas Garnett, a physician in practice at Harrogate in the year 1791, and afterwards Professor of Chemistry at the Royal Institution, London, in his treatise on 'The Mineral Waters of Harrogate,' wrote as follows :—

"'In one of the sulphur wells situated in the bog, I have discovered alum, and I suspect salited clay. In a chalybeate water near the road, and not far from the Crescent garden, the iron is dissolved by the muriatic acid.'

"Dr. Adam Hunter, a physician resident in Leeds, in his book entitled 'The Waters of Harrogate and its Vicinity,' published in 1830, commenting upon these statements, says:—

"'The reader will, I believe, look in vain for alum or muriate of iron in the waters referred to.'

"The discovery of ferrous chloride in 1865 in one of the Harrogate spas, near the site indicated by Dr. Garnett, and the substance of my paper this evening, strongly support Dr. Garnett's observations. So far back as 1733 Dr. Thomas Short, of Sheffield, F.R.S., mentions an alum well in the bog-field at Harrogate, describing its position, the nature of the ground, and the experiments he made with the water.

"Dr. Garnett, referring to these observations, says:—

"'From Dr. Short's experiments it seems to have been a chalybeate water in which the iron is held in solution by the sulphuric acid;' then he adds: 'I have found two or three springs of this kind in the bog, very near some sulphur wells.'

"Since Dr. Garnett's residence in Harrogate a period of eighty years has elapsed, and the existence of the alum well passed quite out of memory. It was not until 1870, when excavations were made in

the bog-field for the purpose of increasing the supply of sulphur-water, that this aluminous water again came to light; the excavation was afterwards deepened, earthenware pipes were put down, forming a well about 4 feet deep and 14 inches diameter, where the water slowly collects. This aluminous water is of a pale reddish-brown colour, strongly acid to litmus and of very astringent taste; after keeping a short time, if exposed to the air, a portion of the iron is precipitated as basic sulphate, and the protosulphate gradually changes into the ferric salt.

"The ground in its vicinity is strongly acid to litmus, tastes austere, even after heavy and continuous rains; depressions in the ground after a shower, more particularly in summer, are found filled with water corresponding in colour and taste with that in the well.

"Immediately under the peaty soil in various places around the well, there is a layer of deposit having a sulphur-yellow colour; its appearance has no doubt given rise to the statements of Dr. Short and other old writers, respecting the prodigious quantities of sulphur to be found in the locality. I find, on examination, it contains about 60 per cent. soluble in hydrochloric acid, consisting of SO_3 14·60, Fe_2O_3 29·32, and small quantities of Ca,

Mg, Na, &c.; it bears a remarkable resemblance to two of the ferruginous deposits found in the neighbourhood of the Caspian Sea, the analyses of which by A. Frenzel, are published in the September number of the Journal of this Society.

"To revert to the alum well: its position is remarkable, in being almost surrounded by sulphur wells, which circumstance, together with the surface of the soil being so strongly impregnated with the constituents of the water, strengthens the opinion that the water is of comparatively superficial origin, and is continually produced by natural causes.

"The old deposits from the chalybeate waters situate on higher ground, and the sulphur waters rising through the stratum of shale at a lower level, appear to be the factors in the production of this remarkable water."

III. The Pure Chalybeate Waters.

In solid constituents the Harrogate pure chalybeates compare favourably with any of the same class of medicinal waters:—a class distinguished from others by a small chalybeate impregnation with minimal quantities of saline matter. These waters contain an average charge of iron: the Carbonate of iron water of the Cheltenham Rooms is,

however, one of the strongest pure chalybeates; and they are more *purely* chalybeate in holding a much smaller proportion of accompanying alkaline and earthy salts in solution than kindred waters. From this point of view the Tewit and John's Springs and the Harrogate Pure Chalybeate (Royal Pump Room), like the Tunbridge Wells Spring, are singularly pure solutions of carbonate of iron.

Gases in the Iron Waters.

The charge of carbonic acid gas is more than sufficient to preserve the proto-carbonate of iron in perfect solution at the wells; but though it is at least equal to that of other chalybeate waters in this country, it is below that of many continental springs.

Analyses of the Iron Waters.

	Grains in 20 ozs.									Cubic Inches in 20 ozs.
	Chloride.				Carbonate.					
	Sodium.	Potassium.	Magnesium.	Calcium.	Calcium.	Iron.	Silica.		Total Solids.	Gases.
Kissengen. Analyst, Attfield, 1879.	84·325 Traces	2·678 of Brom	8·174 ides, Io	10·917 dides and	1·107 Lithium.	1·199	·466	Ammonium Chloride ·054; Barium Sulphate ·064; Barium Carbonate ·267; Strontium Chloride ·111	109·342	CO_3 = 2·662; O = ·187; N = ·650
Chloride of Iron. Analyst, Thorpe, 1880.	34·695 Traces	·370 of Magn Cupric	7.165 esium I Chlorid	11·752 odide, Lit e.	— hium Chl	1·381 oride	·177 and	Ammonium Chloride ·051; Iron Chloride 1·652; Barium Chloride ·651; Barium Sulphate ·025; Strontium Chloride ·078; Manganese Chloride ·122; Magnesium Bromide ·043	58·162	CO_3 = 3·285; N = 1·010; Estimated by Professor Miller, 1865.
1881.	—	—	7·198	11·933	—	1·452	·174	Iron Chloride 1·737; Barium Chloride ·734; Manganese Chloride ·107	—	
Alexandra Water. Analyst, Davis, 1870.	22·046 Traces	·141 of Magn	·592 esia, Lit	— hium, Iod	1·137 ·73 Mag. Carb. ine, Brom	·752 ine, A	·084 mmo	Calcium Sulphate ·137 nia.	26·585	CO_3 = 2·23; O = ·31; N = 1·23
Carbonate of Iron. Analyst, Muspratt, 1865.	1·456 Traces	·019 of Lithi	1·643 um Chl	·289 oride.	·043	·755	·025	Calcium Sulphate ·953	5·183	CO_3 = ·973; N = trace.
Harrogate pure Chalybeate. Analyst, Muspratt, 1870.	·080	—	·130	·190	·281	·376	·005	Magnesium Carbonate ·116; Sodium Carbonate ·021; Sodium Sulphate ·058; Magnesium Nitrate ·011	1·268	CO_3 = 2·507
Tewit Well. Analyst, Hofmann, 1854.	·035 Traces	·165 of Magn Bromin	— esium C e, Iodin	— arbonate, e and Am	·179 Lithium C monia.	·169 hlorid	·130 e,	Calcium Sulphate ·087; Magnesium Carbonate ·333; Potassium Carbonate ·132; Organic Matter ·083	1·313	CO_3 = 1·480; O = ·050; N = ·690

CHAPTER IV.

THE BEARING OF THE CHEMICAL DATA ON SOME OF THE CURATIVE EFFECTS OF THE WATERS.

THE mineral waters of Harrogate—like many others elsewhere—are compound remedies; for they contain for the most part several curative agents blended together in different proportions, some of which are recognized in medical practice as reliable medicines. In the Old Sulphur Well, for example, the chemist has indicated the presence of at least sixteen different substances, each of which—like one of the several parts of an intricate machine—may take its share of work while operating on the system. But, inasmuch as every constituent while endeavouring to assert its individual powers—as when administered alone—is probably either aided, or thwarted, or modified in its actions on every side by the operations of the others, it becomes next to impossible to foresee what will be the outcome of all the intricate interactions of the components of such a mineral water—though we may know fairly well the properties of each as an independent remedy. It therefore follows, the cura-

tive employment of medicinal springs—such as these —cannot be predicted from analytical results, but must proceed from intelligent experience. But the chemical data are not altogether valueless if they illustrate the remedial virtues of the waters to those not practically conversant with them; and undoubtedly they provide for the non-medical the best assurances of a reasonable belief in the efficacy of these natural remedies, and they enable a better conception of their curative power to be realized than can be provided by mere assertion and laudation. To this end the reader may peruse the following notes, and form his own judgment as to how far the proved power of the Harrogate Waters in curing or alleviating certain diseases may be traced in the truths which physiological inquiry and medical experience have established as to the properties of the leading constituents used separately as curative agents. It should be premised that only those components are here referred to as appear—in the quantities of the waters usually taken—as a rule in doses which are equivalent to such as are regarded in medical practice as curative or efficient: this limitation of the survey, however, should not exclude the probability of the remedial operation of the remaining substances which exist in smaller proportions; for it is but an outline of the

prominent features of the country, from which details apt to confuse the view have been excluded.

I. Physiological action and curative properties of some of the leading constituents of the Harrogate Waters.

1. *Chloride of Sodium.* The large absolute and relative proportion of Chloride of Sodium in all the Saline Waters suggests its prominence as a curative constituent; and the presence of it in all the fluids of the body as a constant and predominant mineral ingredient indicates the physiological importance of it, and the purely physiological character of its curative operation when administered in these mineral waters. Its properties have been well defined by observation and experiment.

The immediate action of Chloride of Sodium on the Alimentary organs is to stimulate the glands of the stomach to increased secretion, to tone the gastric mucous membrane, and to invigorate the digestive apparatus. It promotes the digestion and assimilation of the Albuminous and Starchy foods; and, being the solvent of the fibrin generators of the Lymph and Chyle, the rôle it plays in building up the corresponding constituents of the Blood may be inferred.

Administered in sufficient quantity it acts as an aperient; as in the Old Sulphur Well, the Strong Montpellier Sulphur and the Kissengen—when its purgative property is doubtless aided by that of Chloride of Magnesium present in these waters. Purgation by Chloride of Sodium waters—such as these—is less to be feared on the score of lowering the system than by those which act on the bowels by virtue of Sulphates; for the latter more readily excite catarrh of the bowels, more quickly lower the tone of the organism, and cannot be continued for so long a period without interruption as the Chloride aperients. The action of Sulphated waters, in fact, rests mainly on local irritation: while Chloride waters perform the same work in a milder manner; a difference in operation which possibly hinges on the fact, that Chlorides in aperient doses are normal constituents of the blood and of all the secretions, and being merely augmented for the time, their physiological are exalted into curative powers, while Sulphates are far from prominent components of the fluids, and act as local irritants. Hence, concentrated Chloride Waters—such as these—induce purgation in the most natural way attainable, and with the least expenditure of the forces of the organism.

Chloride of Sodium is the principal mineral con-

stituent of the blood and of all the fluids, which are either absorbed into the blood or flow from it. In the blood it keeps the fibrin dissolved, and it checks the solution of the red blood corpuscles.

It is intimately associated with the changes which every particle of the body is continually undergoing in the process of nutrition, by which new material is deposited in the place of that worn out and removed; for, it predominates in all the secretions concerned in assimilation—viz., the saliva, the gastric juice, the intestinal juice, the pancreatic juice, and the bile —and is linked with the product of waste thrown out by the kidneys. The power of Chloride of Sodium to stimulate the construction of the tissues is suggested by the presence of it in large quantity in the fluids in which rapid growth is going on. It accelerates that important circulation of the fluids of the body outside the closed walls of the blood vessels; thereby it the more readily supplies in solution materials for the reconstruction of the tissues, and removes the products arising from their waste: it thus stimulates both sides of nutrition.

The experiments of Zabelin and Woronichin showed that Chloride of Sodium is the agent which effects the absorption and storing up of Iron in the blood; and that which robs the iron-holding tissues

of this metal, and removes it from the system is Chloride of Potassium. It is interesting to note that in the Chloride of Iron, the Kissengen and the Alexandra waters—but especially the Chloride of Iron—the salt which assimilates Iron is in full force, while that which throws it out is practically absent.

2. *Chloride of Magnesium*—A valuable aperient.
3. *Chloride of Calcium*—A well proved remedy in Scrofula, and especially in the removal of Scrofulous enlargements and Skin diseases.
4. *Barium Salts* have been successfully prescribed in Scrofula, Skin diseases, and in debility of the Heart, blood-vessels and nervous system.
5. *Sulphides* are believed to hasten the destruction of the red blood corpuscles in the portal vein, and thus to relieve congestion of the Liver; to favour the development of the scarf-skin in certain forms of Eczema; and to sooth inflammatory states of the skin and mucous membranes. The Alkaline Sulphide—largely present in all the Harrogate Sulphur waters—probably undergoes reactions with the acids of the gouty and rheumatic.
6. *Iron Salts*—Iron is an essential constituent of the red blood corpuscles. When these are imper-

fectly developed, or when from any cause their iron-holding contents become reduced, the defect is, as a rule, speedily and effectually met by supplying Iron in assimilable forms beyond that ordinarily contained in the food. It is likewise valuable in the treatment of various forms of debility, and favours the constructive side of nutrition.

II. The principal diseases in the treatment of which experience has shown the Harrogate Waters to be valuable.

All the springs form a harmonious series of natural curative agents, the keynote of which is acceleration of tissue-change. The remarkable—indeed unique—number and variety of the waters enable the prescriber to vary the combinations according to the requirements of cases; he may, for example, maintain an equally balanced increase of building and of unbuilding, or he may cause one of these processes to predominate, or he may render the movement of tissue-change irregular—now in the ascendant a quickening of the production and removal of waste, and now of construction; but throughout, the keynote remains true. The radical action of these natural remedies is exerted on the

blood and the tissues; and it is one which stimulates both sides of nutrition—the removal of the out-going and the substitution of the in-going molecule—and is, in fact, the operation of Chlorides on the disintegration and construction of the tissues.

But in Harrogate these renovating agents are linked, on the one hand with substances which specially favour construction, such as the salts of Iron, Barium, &c.; and on the other with Sulphides, which hasten disintegration.

The therapeutic unity of the whole series of mineral waters is a valuable acquisition to Harrogate, and offers many practical advantages in the treatment of cases which resort to it—such as are not provided by any other Spa at home or abroad.

The curative range of this system of natural remedies embraces a great variety of chronic diseases, such as the following: *—

1. *Derangements of the digestive organs:* especially in the gouty, the scrofulous, and those whose blood and tissues are impoverished.

2. *Constipation.*

3. *Disorders of the Liver:* such as arise from

* For details on these medical matters, the reader is referred to the author's work, "The Harrogate Waters: Data Chemical, and Therapeutical."

congestion or exhaustion of the organ. Jaundice. Plethora of the abdominal and pelvic organs. Malarial diseases of the Liver or Spleen.

4. *Impoverished blood. Defective development. The tissue exhaustion* of retarded convalescence, too rapid growth, chronic ailments, such as diabetes, &c., worry, overtaxed application to business, town life, &c.

5. *Scrofula:* especially when causing Skin affections, enlarged glands, disorders of the organs concerned in digestion and assimilation.

6. *Chronic gout.*

7. *Chronic rheumatism:* Muscular Rheumatism, associated with derangement of the liver.

8. *Rheumatic gout.*

9. *Obesity.*

10. *Skin diseases:* especially Chronic Eczema.

11. *Chronic discharges,* inducing impoverishments of the blood and the tissues.

12. *Feeble Heart,* &c.